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2010 Gulf Island Pond Monitoring Report

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2010 Gulf Island Pond Monitoring Program Report



Maine Department of Environmental Protection
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September 2012

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DEPLW-1238

EXECUTIVE SUMMARY

This report is prepared in accordance with Public Law 2005, chapter 409, An Act to Amend Water Quality Standards, which requires that, by February 1 annually from 2006 to 2011, the Maine Department of Environmental Protection (DEP) shall submit a report on the status of activities undertaken pursuant to this Act to the Joint Standing Committee on Natural Resources. In this regard, DEP's activities for 2010 focused on monitoring of the water quality of Gulf Island Pond (GIP) in the Androscoggin River to assess attainment of Maine's Water Quality Standards, specifically dissolved oxygen (DO) criteria necessary to provide 'habitat for fish and aquatic life', and 'support of indigenous species of fish', as well as provide for 'recreation in and on the water' (swimming, i.e. presence of algae blooms).

As in previous years, aerial flights and water quality monitoring of GIP on Maine's Androscoggin River were undertaken by DEP in the summer of 2010. In addition, water quality monitoring was conducted by consultants for the Gulf Island Pond Oxygenation Project (GIPOP) partnership, i.e. the three pulp and paper mills on the river and the owner of the Gulf Island Dam. The primary goal of these activities was to continue monitoring initiated in prior years to determine compliance with DO criteria and the presence/absence of algal blooms.

The summer of 2010 was a relatively dry one and consequently a good one to evaluate the attainment of Water Quality Standards in GIP, since river flow approached the critical 7Q10 low flow for assessing attainment required by statute (38 MRSA§464(4)(D)). Monitoring during the summer documented the effects of the expanded efforts to improve water quality by the GIPOP partnership, as required by the 2010 modified Department Water Quality Certification and Waste Discharge Licenses issued in accordance with Orders from the Board of Environmental Protection. The existing oxygen injection diffuser at Upper Narrows was modified in 2009 to improve efficiency and a second oxygen injection diffuser was installed at Lower Narrows by the end of June 2010. Oxygen injection rates and discharge limits were also modified during the same time period. Consequently, water quality has improved in both years.

Recreation in and on the Water: Swimming

No algal blooms were observed in 2010, and based on monitoring data obtained annually since 2004, the Department finds that water quality in GIP is suitable for the designated use of recreation in and on the water. In 2010, the mean total phosphorus concentration was similar to those of recent years, all being significantly lower than in 2004, the last year with an algae bloom. In 2010, discharges of total phosphorus from Rumford Paper Company was slightly higher than in recent years since 2007 but continued to be lower than those in 2004, while the discharge of orthophosphorus decreased in 2010. Both are well within permit limits. Discharges of orthophosphorus from Verso Androscoggin LLC were higher in 2010 than levels in recent years, while discharges of total phosphorus were similar to those since 2007. Both are still below peak levels in 2004 and within permit limits.

The mean summer chlorophyll-a concentration was similar to those of 2008 and 2009 and well below the threshold established for lakes (8 micrograms per liter) and the interim threshold for GIP (10 micrograms per liter). Mean chlorophyll-a levels were well below that of 2004 and corroborate the declining trend seen from 2004 to 2008. Secchi disk (SD) transparency was above the 2 m threshold used for blooms in lakes for all sampling dates. Mean SD transparency for the entire summer was similar to those of 2008 and 2009, both relatively high river flow years.

Habitat for Fish and Aquatic Life and Support of Indigenous Species of Fish: Dissolved Oxygen

In general, DO levels were improved compared to previous years and are at the highest levels observed since recent monitoring of GIP was initiated in 2004. DO concentrations were monitored to determine attainment of the minimum 5.0 parts per million (ppm) criterion and monthly average 6.5 ppm criterion (when and where temperatures were 22°C or lower). The data were analyzed considering spatial (longitudinal and vertical) and temporal aspects. Longitudinally, within GIP, minimum and monthly average DO criteria were met at stations above the Lower Narrows (LN) diffuser for all sampling dates, after July 1, 2010 when the new diffuser at LN began operation. Below the LN diffuser, DO concentrations have improved from previous years, but concentrations were still below the minimum criteria or the monthly average criterion for many days. Although the depressed DO levels were usually restricted vertically to 1-3 m (<10 feet) in or near the thermocline and in the deeper parts of the impoundment, these were the only depths where temperatures were suitable to support all indigenous species of fish as required by statute. Consequently, in the absence of adequate DO levels at the required depths, Maine's Water Quality Standards are not fully met. As was the case with the Water Quality Certification issued in 2005 for Florida Power and Light's operation of the Gulf Island Hydropower station, the remaining water quality issues are not considered due to current upstream discharges.

The location of low DO concentrations in the area of the thermocline and in deeper layers where mixing is inhibited and the generally high DO readings above this area indicate that sediment oxygen demand (SOD), resulting primarily from past inputs of total suspended solids and settled algae due to past inputs of nutrients, is likely the predominant cause of low DO levels there. Permit limits for Biological Oxygen Demand (BOD) and phosphorus, and to a lesser extent total suspended solids, were reduced in 2005, 2008, and 2010. Discharges of phosphorus from the mills are now well below those from 2004 and phosphorus remains within permit limits. It is expected that compliance with the current permit limits will further reduce SOD and allow full compliance with the DO criteria in time.

GULF ISLAND POND WATER QUALITY MONITORING REPORT, 2010

Introduction

Water quality monitoring of Gulf Island Pond (GIP) on Maine's Androscoggin River was undertaken by the Maine Department of Environmental Protection (DEP) and the Gulf Island Pond Oxygenation Project (GIPOP) partnership in the summer of 2010. The primary objective of these activities was to continue monitoring initiated in 2004 and earlier to determine the attainment of Maine's water quality standards (WQS), specifically dissolved oxygen (DO) criteria necessary to provide "habitat for fish and aquatic life", and "support of indigenous species of fish", as well as provide for "recreation in and on the water" (swimming, *i.e.*, presence of algae blooms). A second objective was to gather more data to help determine total phosphorus (TP) and chlorophyll-a (CHLa) thresholds for algal blooms in GIP. A third objective was to determine the effect of recent modifications in point source discharges, increased efficiency of the original oxygen injection system and installation of a second oxygen injection location on increased attainment of WQS.

To ensure attainment of DO criteria, modifications to Verso Androscoggin LLC's MPDES permit finalized in June 2010 (as provided for by Special Condition P, *Reopening of Permit for Modification*, of a February 7, 2008 Board order) include a reduction in monthly average BOD5 from 4500 pounds per day to 4400 pounds per day, an increase in ortho-phosphorus from 22 pounds per day to 28 pounds per day, and a modification of the oxygen injection requirements. Modifications to the Rumford Paper Company MPDES permit finalized in June 2010 (as provided for by Special Condition K(b), paragraph c of Rumford Paper Company's September 21, 2005 permit, and as modified on appeal by the Board) includes a modification of the oxygen injection requirements.

In June 2010 DEP ordered the Gulf Island Pond Oxygenation Project (GIPOP) partnership to revise the operational plan for oxygen injection into Gulf Island Pond. The order requires that FPL Energy Maine Hydro LLC shall, in partnership with Verso Paper, Rumford Paper, and Fraser Paper, or their successors-in-interest, inject oxygen at Upper Narrows at a rate of up to 24,279 lbs/day at an oxygen transfer efficiency of 54%, and at Lower Narrows at a rate of up to 34,490 lbs/day, or 33,691 lbs/day if the wastewater from the Wausau-Mosinee Otis mill is no longer sent to the Verso mill for treatment, at an oxygen transfer efficiency of 75%, or at equivalent rates and efficiencies. This represents an increase in oxygen transfer efficiency at Upper Narrows from ~ 33%, that was accomplished by a modification of the diffuser system in 2009, and extension of the oxygen supply lines ~2 miles down river to Lower Narrows to a new parallel diffuser system in 2010. The new plan was designed to deliver sufficient oxygen to meet DO criteria in Gulf Island Pond between June 1 and September 30 annually with all upstream point sources discharging at their final license limits. Oxygen is injected at varying rates as a function of average river flow and temperature conditions. Under the worst case conditions [river temperature greater than 24°C (Celsius) and river flow less and or equal to 3,500 cubic feet per second, expressed as three-day averages at Turner (Center) Bridge, which crosses Gulf Island Pond about 7 miles upstream of Gulf Island Dam], oxygen will be injected at the maximum rates specified in the Department's June 2010 order. The injection rates are based on the results of the Department's revised water quality modeling at 7Q10 flow conditions, a maximum river temperature of 26°C, with all point sources upstream of Gulf Island Pond discharging at their license limits, and with an added margin of safety of 4.2 %. Interim rates are based on modeling conducted by Dr. David Dilks of LimnoTech on behalf of the GIPOP Partnership, with an

added margin of safety of 4.2%, and are based on the same temperature and flow threshold conditions as have been approved for the operation of the Upper Narrows oxygen injection system.

An algae bloom in Maine lakes is currently defined as a planktonic growth of algae which causes Secchi disk transparency to be less than 2 meters. [*Regulations Relating to Water Quality Evaluations*, 06-096 CMR 581 (effective May 4, 1996)] However, in waters where color exceeds 30 platinum cobalt units (PCU), Secchi disk transparency may be significantly influenced by color as well as algae. Therefore, for colored waters, such as GIP, CHLa is a better measure of blooms. In lakes, blooms are associated with CHLa concentrations greater than 8 micrograms per liter (ug/l). Given their higher current velocities, rivers may have higher thresholds of CHLa for blooms. Also, observations of a bloom by the general public include an aspect of visibility, which is affected by light, sky cover, and turbulence (velocity, wind and wave action) on the surface of the water. Although GIP is statutorily classified as a river, it sometimes acts like a lake or a hybrid of the two where the algae are not uniformly distributed as would be expected in a lake. Therefore, the CHLa threshold for a visible bloom in GIP may be different, in the range of 8-12 ug/l (Paul Mitnik, 2005). The total maximum daily load (TMDL) calculated for GIP, approved by the federal Environmental Protection Agency (EPA) on July 18, 2005, sets a pond average value of 10 ug/l CHLa as the interim threshold. For calculation of the pond average, CHLa will be included only at stations where a bloom has been observed. The TMDL also specifies that annual monitoring should continue to further refine a CHLa threshold for blooms.

Given the uncertainty in knowing the threshold for an algae bloom in GIP, water quality data specific to GIP have been collected and correlated to observations of bloom conditions in 2004-2010. Aerial observations of GIP for bloom and scum layers are documented visually in conjunction with ambient monitoring of CHLa.

There were three separate monitoring studies in the 2010 program;

- Aerial flight observations of the presence/absence of wide spread algal blooms and unusual conditions in the watershed and water quality sampling at Lower Narrows in June and Island Station after June on the same days of aerial observations by DEP;
- Water quality sampling at several stations by the Gulf Island Pond Oxygenation Project (GIPOP) partnership; and,
- Continuous monitoring of temperature and DO at the Turner (Center) Bridge, the Deep Hole station, and dam station (Figure 1) also by the GIPOP Partnership.

Since there were some similar parameters measured in each of the three studies, results will be discussed by parameter, first for aerial flight observations and river flows, next by phosphorus (both ambient and discharge levels), chlorophyll-a, and Secchi disk transparency, and finally for temperature and DO, for each study.

1. AERIAL FLIGHT OBSERVATIONS AND RIVER FLOW

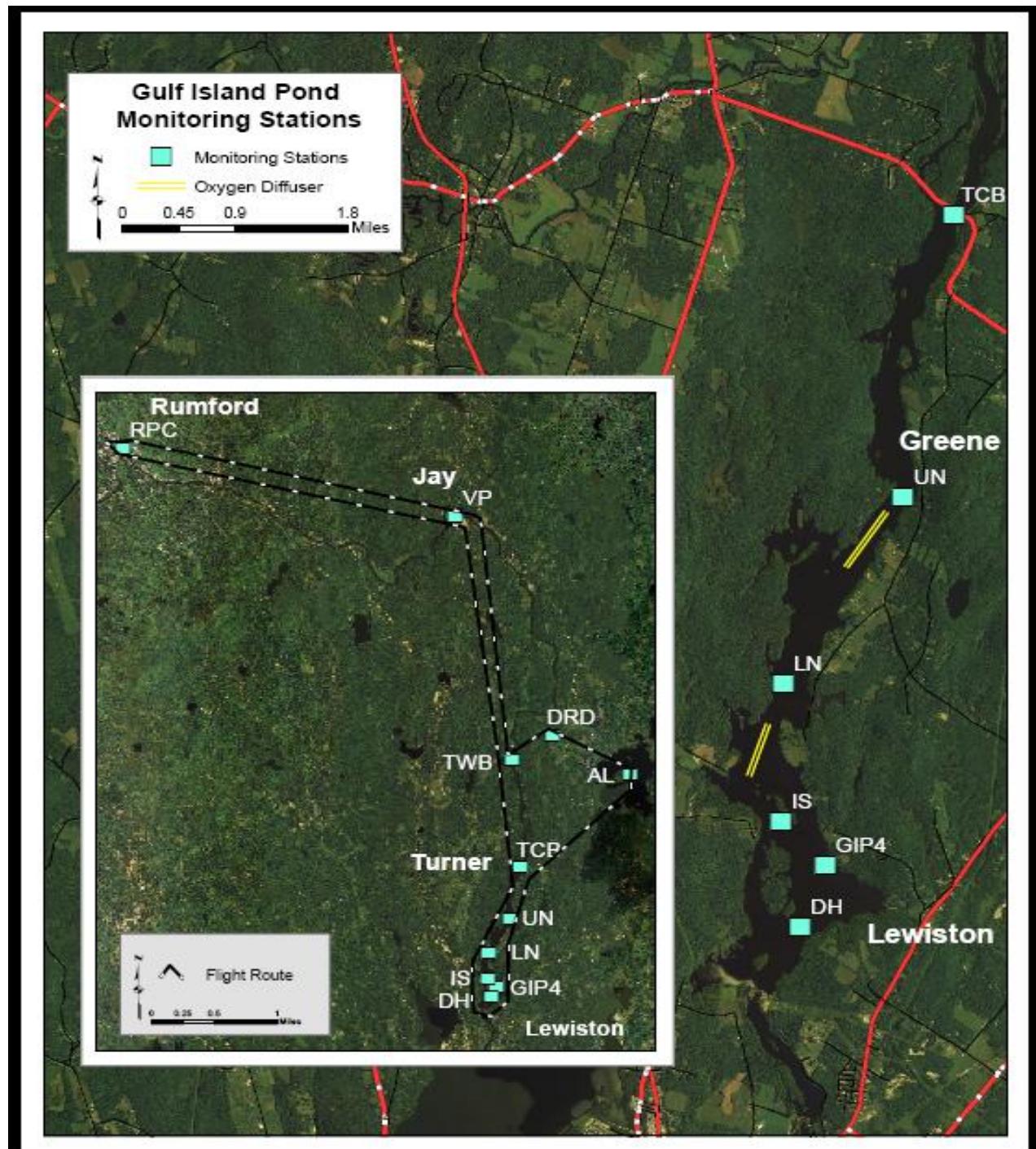
During the summer of 2010, the Maine Department of Environmental Protection (DEP) conducted weekly (weather permitting) aerial monitoring of Gulf Island Pond (GIP) and the Androscoggin River to determine the extent and conditions for algae blooms. The aerial monitoring was conducted by DEP staff from a commercial seaplane base on the Androscoggin River in Turner. A four-person, high wing single-engine seaplane (SES) was utilized and afforded the opportunity to land on the river to collect water chemistry data at the Lower Narrows sampling station in June and a different location at the Island Station after June, as well as to also collect water column samples at other locations if bloom conditions were observed. Installation of the new diffuser injection point at Lower Narrows in June 2010 occurred at the location of DEP's historic Lower Narrows sampling station. Consequently, to evaluate the effect of the new diffuser, a new station (Island Station), approximately 1 mile below Lower Narrows, was sampled by DEP beginning on July 7, 2010. The last sampling event at the historic Lower Narrows station was conducted on June 29, 2010. Lower Narrows is 11-15 meters deep, depending on rainfall and weekly drawdown for hydropower generation, while the Island Station is 20-24 meters deep under the same conditions.

Aerial observations, water column samples and ambient temperature and DO data were collected roughly weekly from July through August, after startup of the new diffuser at Lower Narrows (total of 8 successful monitoring events). Based on observed ambient river conditions (temperature, flow, DO profile, etc.) and cooling weather conditions, the Department did not conduct aerial monitoring events after August 31st. The seaplane had a scheduled departure from Turner at 10 am and typically flew from Turner to Rumford prior to landing at the Lower Narrows (LN) or Island Station (IS) monitoring stations in order to collect water chemistry data. All data were recorded on a standard log sheet.

There were eleven locations that were part of the aerial monitoring program (Figure 1). The first 6 were also water quality monitoring stations. Moving from GIP dam upriver they are denoted as:

- (1) Deep Hole-DH;
- (2) Gulf Island Pond #4-GIP4;
- (3) Island Station-IS
- (4) Lower Narrows-LN;
- (5) Upper Narrows-UN;
- (6) Turner Center Bridge-TCB;
- (7) Twin Bridges-TWB;
- (8) Androscoggin Lake-AL;
- (9) Dead River Dam-DRD;
- (10) Verso Paper discharge -VP; and
- (11) Rumford Paper discharge- RPC.

Figure 1. Androscoggin River Aerial Monitoring Stations and Gulf Island Pond monitoring stations



The flight to Rumford included certain locations upriver from Gulf Island Pond in order to determine potential sources of nutrient loading to the watershed. The aerial survey route was northerly to the Upper Narrows monitoring station and northerly along the river to Center Bridge, Androscoggin Lake, Twin Bridges, and then to the paper mills in Jay and Rumford. A southerly route was then taken to the most southerly monitoring stations (Gulf Island Pond monitoring station #4 and to the Deep Hole). At these locations photographs were taken at various aspects in order to collect representative images of the monitoring locations and to document any algal blooms or other water quality issues. Digital photographs of the mill discharge outfalls were also taken and compared with reported discharge levels. These photos documented the presence of visible plumes from dischargers on the Androscoggin River. These plumes represent potential non-attainment of the recreational designated uses in Maine's Water Quality Standards, which prohibits the "*Discharge of pollutants to waters of the State that imparts color, taste, turbidity, toxicity, radioactivity or other properties that cause those waters to be unsuitable for the designated uses and characteristics ascribed to their class.*" [Classification of Maine waters, 38 M.R.S.A. § 464(4)]. Effluent plumes from the Verso mill was observed on four monitoring events (June 4, 8 and August 17, 31). No algal blooms were documented within the Androscoggin River from aerial observations during 2010.¹

¹ However, on July 20, 2010, the Department observed a significant algal bloom in a small waterbody known as Cherry Pond that is adjacent to the main stem Androscoggin River but physically isolated by an earthen causeway. Cherry Pond is located in the Town of Greene just north and due east of Lower Narrows station. A similar bloom condition was observed on August 11, 2009, at which time Department staff conducted ground observations of Cherry Pond and collected surface grab samples for algae identification. During the ground observation effort, Department staff did not observe the presence of culverts or other structures that would allow the free exchange of surface waters from Cherry Pond to or from the Androscoggin River. Department staff did not observe any discoloration or bloom type conditions in the river immediately adjacent to Cherry Pond. During routine aerial observations conducted on August 31, 2010, Department staff observed that the algae bloom in Cherry Pond had greatly diminished. The Cherry Pond bloom does not appear to be associated with water quality conditions in the Androscoggin River.

River Flow

Summer of 2010 was drier than average. River flow (mean daily discharge) was below the long term median for essentially the entire summer except for 4 storm events (Figure 2). Mean flows for June, July and August were as low or lower than all recent years except for June 2004 (Figure 3). Consequently, the mean for the summer was lower than all recent years except for 2004 (Figure 4).

Figure 2. Mean daily discharge June to September 2010

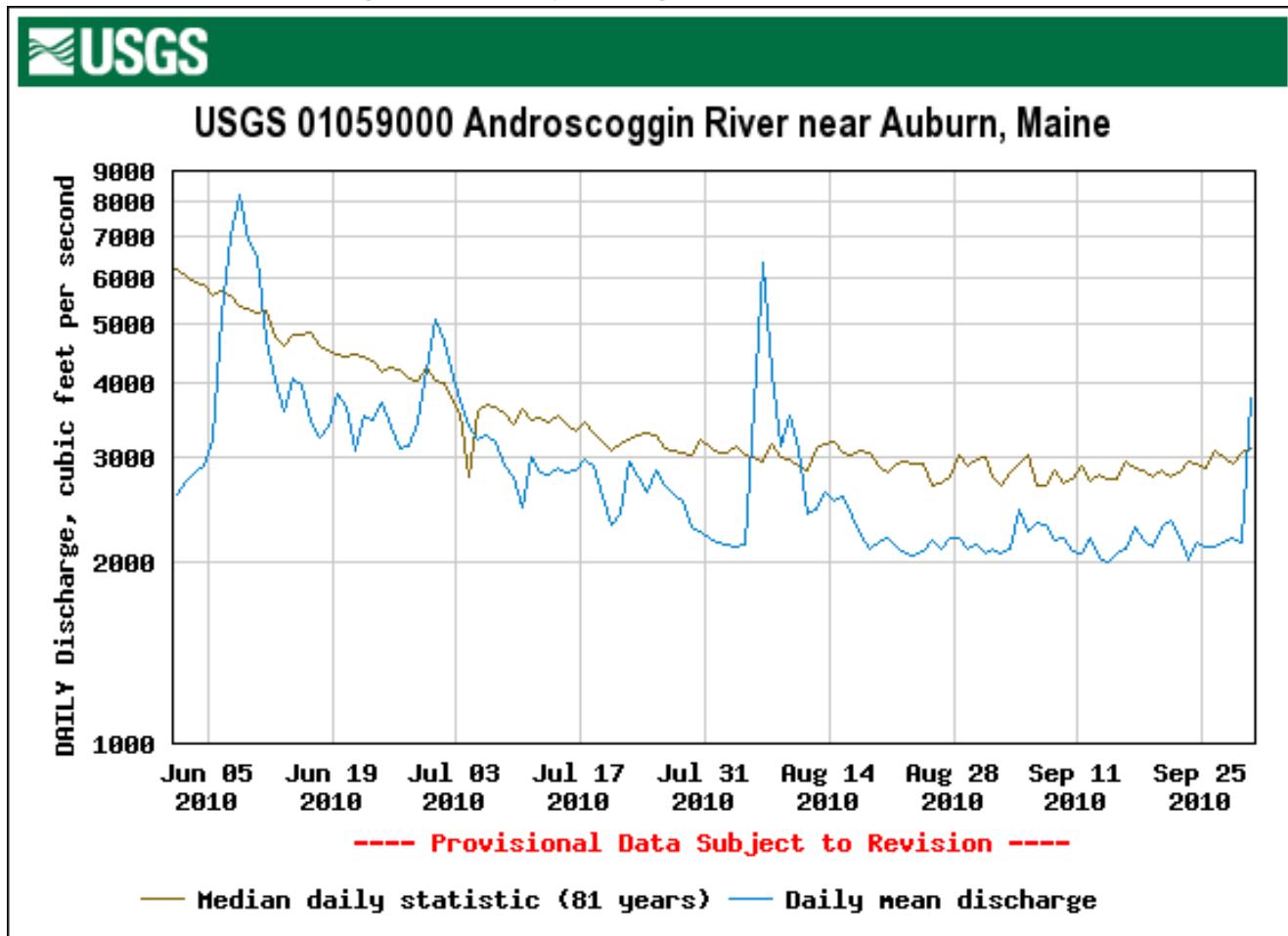


Figure 3. Mean monthly flow (Q_r, cfs) of the Androscoggin River, Auburn Maine, 2010

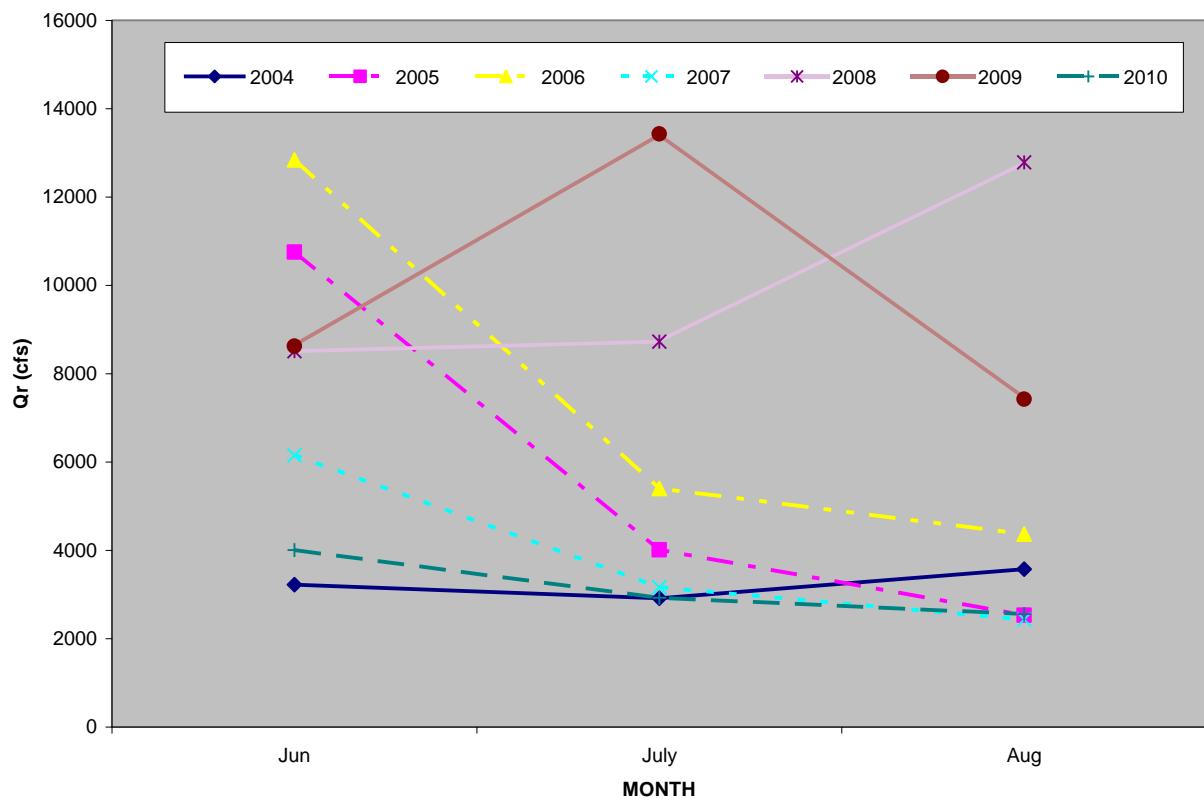
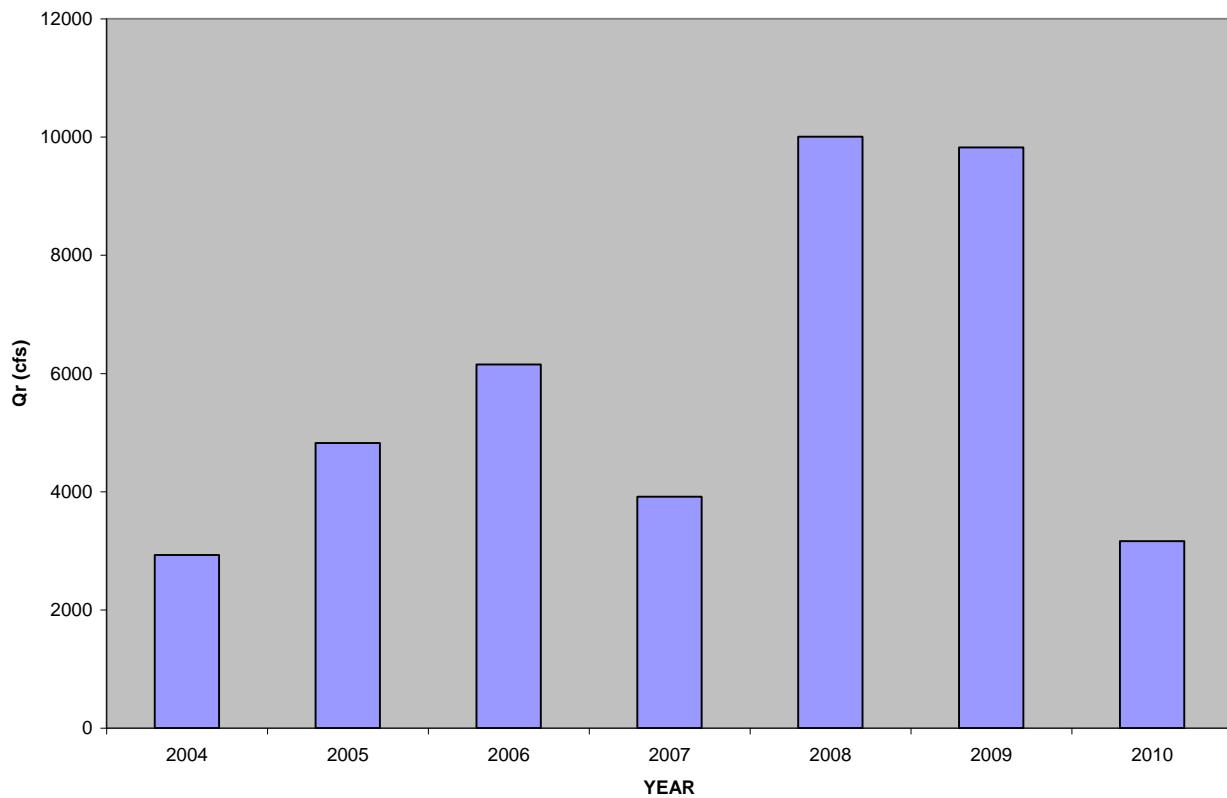


Figure 4. Mean summer flow (Q_r) of the Androscoggin River at Auburn, Maine, 2010



2. PHOSPHORUS, CHLOROPHYLL, SECCHI DISK TRANSPARENCY

Total Phosphorus

DEP Study

DEP collected samples for total phosphorus (TP) during the weekly aerial flights in 2010 at Lower Narrows (LN) in June and at Island Station (IS) from July through August. The sampling station was moved from LN to IS after the new oxygen injection point at LN began operation July 1. IS is ~ 1 mile downstream of LN and TP concentrations would not be expected to be different. Additional samples were to be collected at any other locations where a bloom was observed, but no blooms were observed in 2010. The highest TP concentration (24 ug/l) occurred on August 25, but concentrations did not vary much throughout the summer (Figure 5, Appendix 1). This was during a period of low river flow and TP concentrations were lower during storm events (Figure 2), which suggests minimal impact of non-point sources (NPS) of TP. All TP concentrations exceeded the general threshold for blooms in uncolored lakes (15 ug/l). Compared to uncolored lakes (<30 PCU), however, higher TP is usually required in colored lakes (>30 PCU) to cause a bloom, due to chelation of TP by tannins and lignins responsible for the high color and also due to the limited depth of sunlight penetration to depth. GIP usually has color 40± PCU at summer flows due to the mill discharges. From a regression developed from Maine summer lakes data (n= 3819) with contemporaneous color, TP, and chlorophyll-a data, with a color of 40 PCU, an average TP=19 ug/l and TP= 26 ug/l was needed to produce chlorophyll-a of 8 ug/l and 10 ug/l (potential bloom levels) respectively, but the correlation coefficient was low, indicating that there is wide variability and that there may be other factors involved. GIP has a shorter flushing time than most lakes, which might result in a different response to TP. At LN mean TP for 2010 (20 ug/l) was near the lower threshold and generally similar to those of recent years except for 2004, which was significantly higher than all years since (Figure 6).

Figure 5. Total phosphorus (TP) concentrations in GIP at Lower Narrows (LN) and at Island Station (IS) 2010

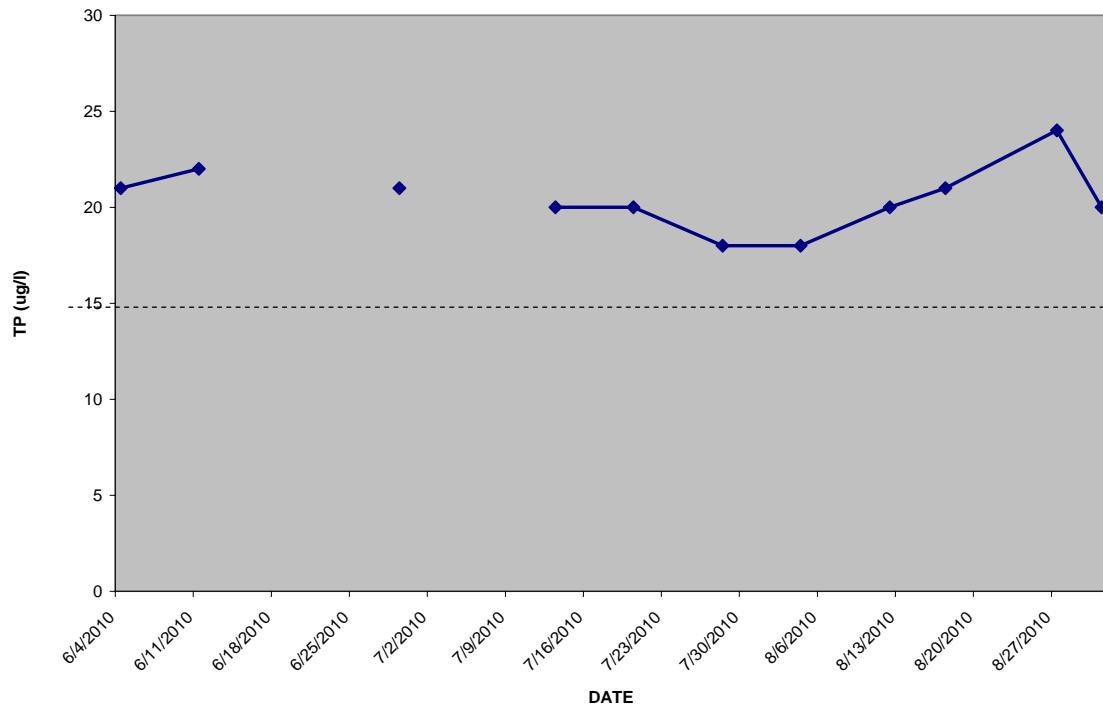
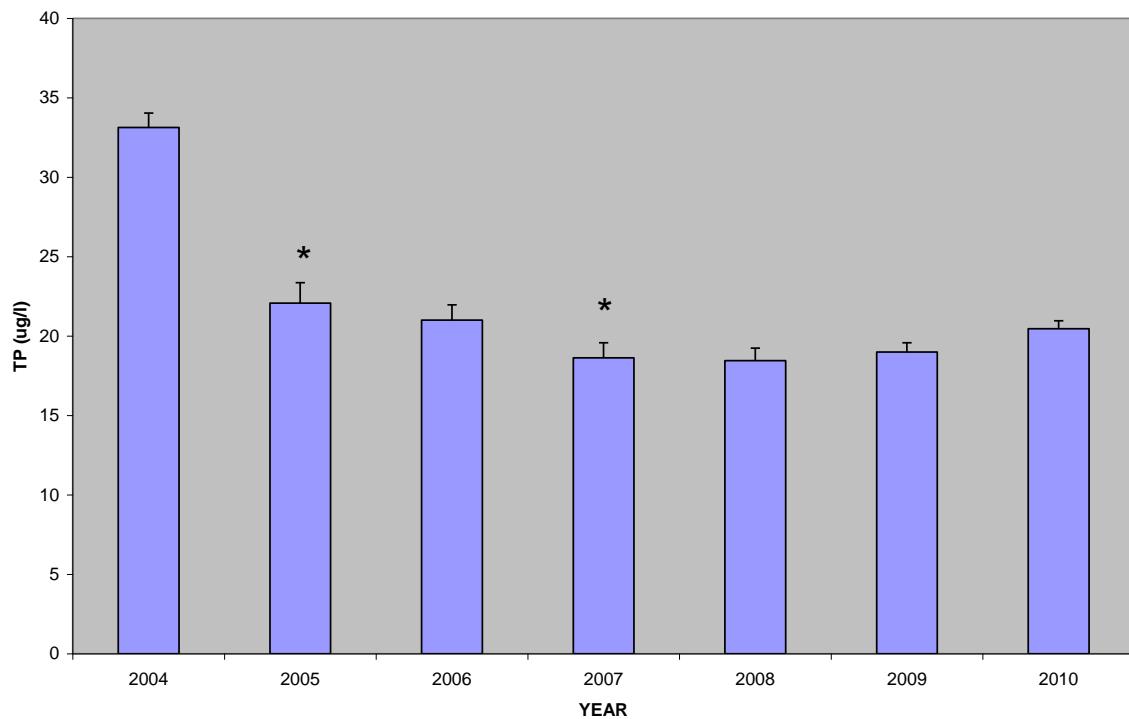


Figure 6. Mean (+se) summer total phosphorus (TP) concentrations in GIP at Lower Narrows (LN) 2004-2009 and at Island Station (IS) 2010

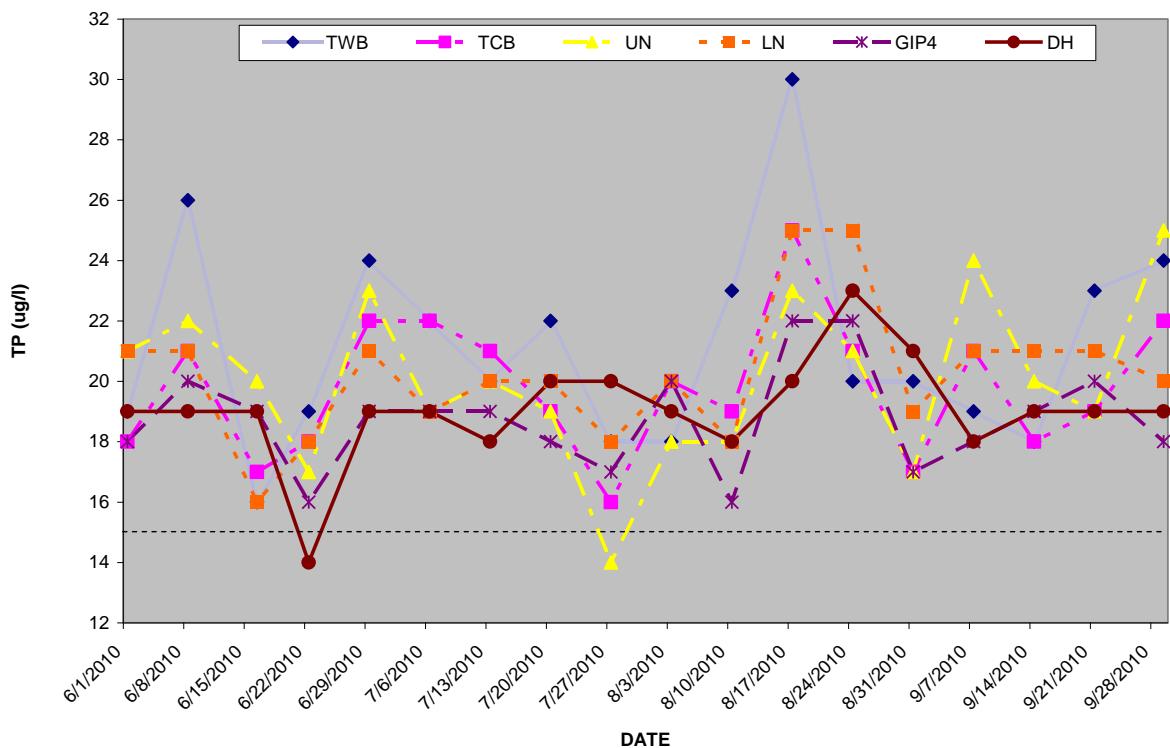


Acheron/GIPOP study

Acheron measured Secchi disk transparency and collected and analyzed samples weekly for Ortho-Phosphorus (OP), TP and chlorophyll-a at six locations listed in DEP's aerial monitoring program, i.e. Twin Bridges, Turner Center Bridge, Upper Narrows, Lower Narrows, GIP 4 and the Deep Hole, for the GIPOP Partnership. The Upper Narrows and Lower Narrows sampling sites were relocated during the first week of July due to the installation of new oxygen diffuser in the Lower Narrows section of the pond. The Lower Narrows sampling site was moved ~700 meters upstream of its initial location. Because the new Lower Narrows site was much closer to the Upper Narrows site, the Upper Narrows site was also moved ~1500 meters upstream of its initial location to provide greater separation between sampling sites, and above the diffuser to ensure that the Upper Narrows site observations would not be affected by the Upper Narrows oxygen diffuser.

TP concentrations in the upper (euphotic) zone were higher than the general threshold for algal blooms in lakes (15 ug/l) for all but one sampling date for each of two stations (Figure 7, Appendix 2). In general, concentrations were highest at the upstream stations and decreased downstream, perhaps due to dilution, algal uptake, or sedimentation. Although DEP and Acheron sampled different stations on different days, mean summer TP concentrations measured by Acheron at LN and by DEP (the Maine Health and Environmental Testing Lab, HETL) at IS were the same (20 ug/l). These two stations are approximately 1 mile apart. Most of the time, differences were less than 1-2 ug/l with the maximum difference of 4 ug/l on August 17/18. The peak concentrations at most of the stations occurred on August 17 or August 24, corresponding to the peak at IS on August 25 in the DEP samples.

Figure 7. Total phosphorus (TP) concentrations at 6 stations in GIP, 2010

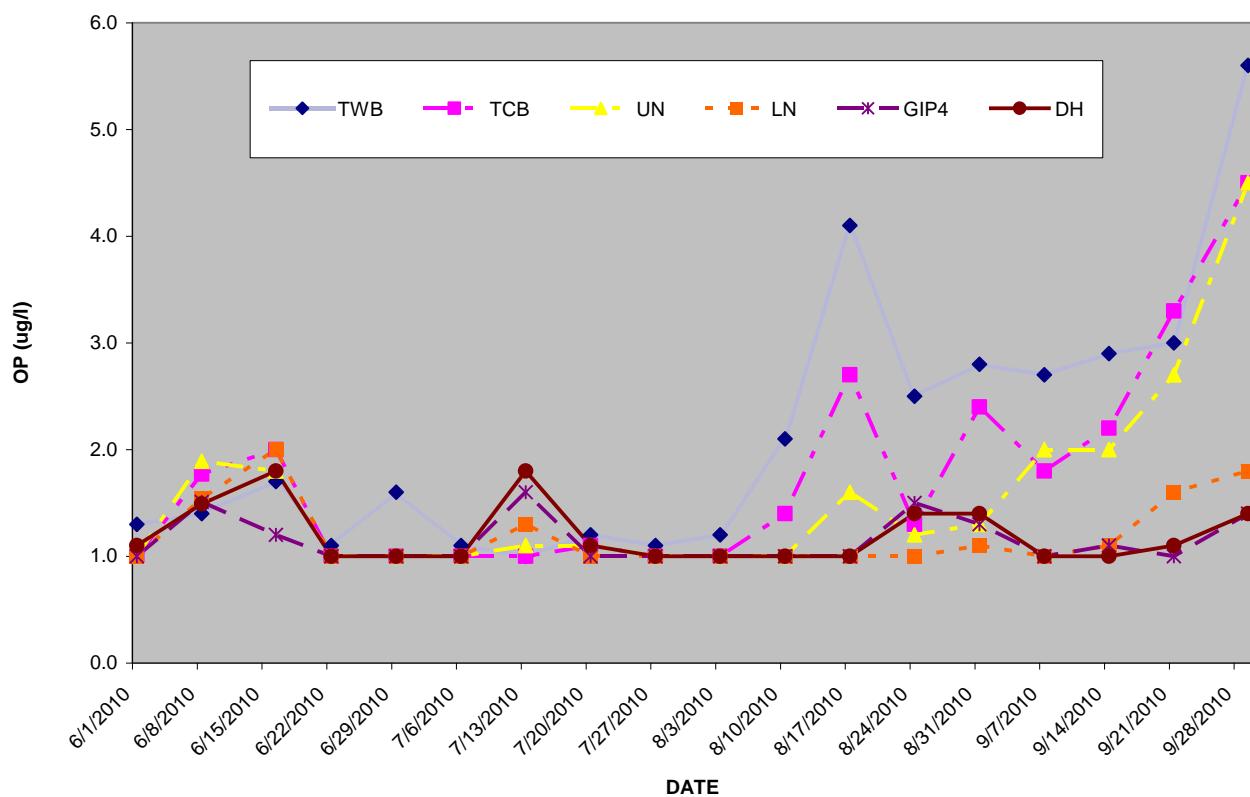


Ortho-phosphorus

Acheron/GIPOP study

Dissolved ortho-phosphorus (OP) values were quite low (Figure 8, non-detects calculated at one half the detection limit at 1.0 ug/l; Appendix 2). Peak concentrations varied among stations. The highest peaks for the three upper stations occurred on September 29, but there was another peak at these same stations at the same time as the peak TP on August 17. Otherwise, OP and TP patterns did not correspond particularly well. There was more variability among stations for OP than for TP. OP was progressively lower downstream during the latter part of the summer, documenting that most OP was taken up by plants within the impoundment, once river flows lowered and temperatures rose.

Figure 8. Orthophosphorus (OP) concentrations at 6 stations in GIP, 2010



Mill Effluent Ortho-Phosphorus (OP) and Total Phosphorus (TP)

The Maine Pollutant Discharge Elimination System (MPDES) permit for the Rumford Paper Co. in August 2006 required that the discharge not exceed 107 ppd and 160 ppd of OP and TP respectively in 2006 and 97 and 152 ppd by 2008. The Rumford Paper Co. has reduced its discharge of OP and TP by more than 50% since 2004 (Figures 9 and 10). Although the discharge of OP increased in 2009 and 2010 and TP increased in 2010, both OP and TP are still well within permit limits.

Figure 9. Mean summer monthly ortho-phosphorus (OP) discharged (ppd, pounds per day) from Rumford Paper Company, 2004-2010

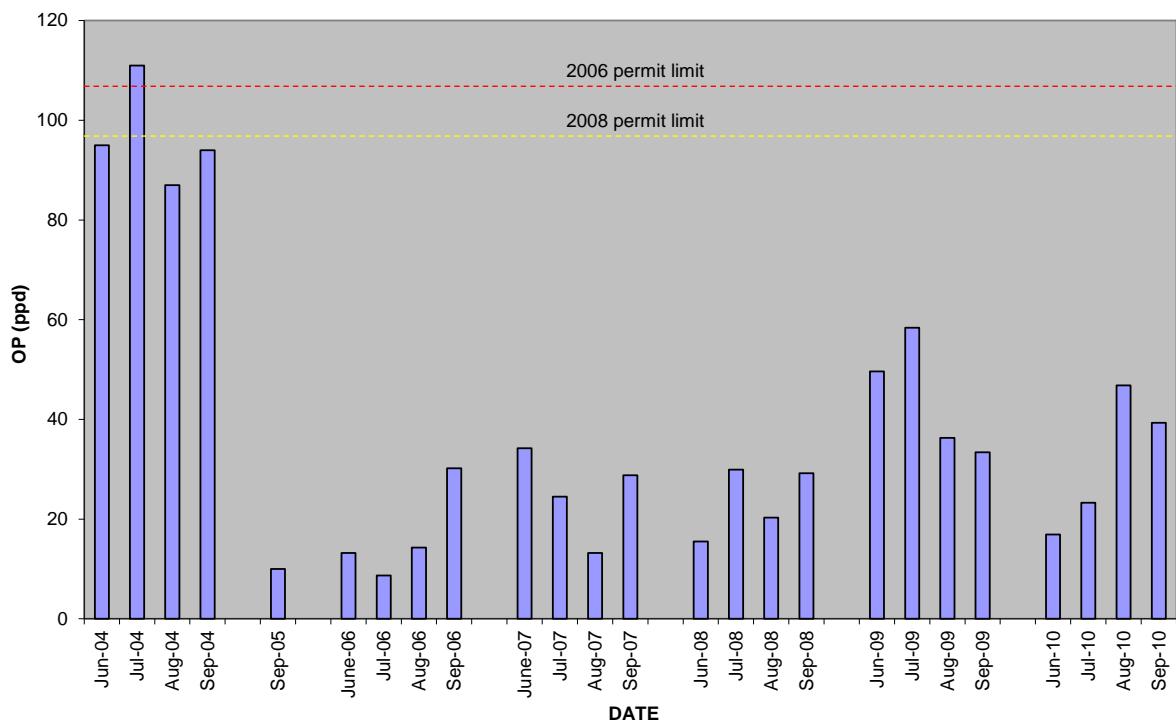
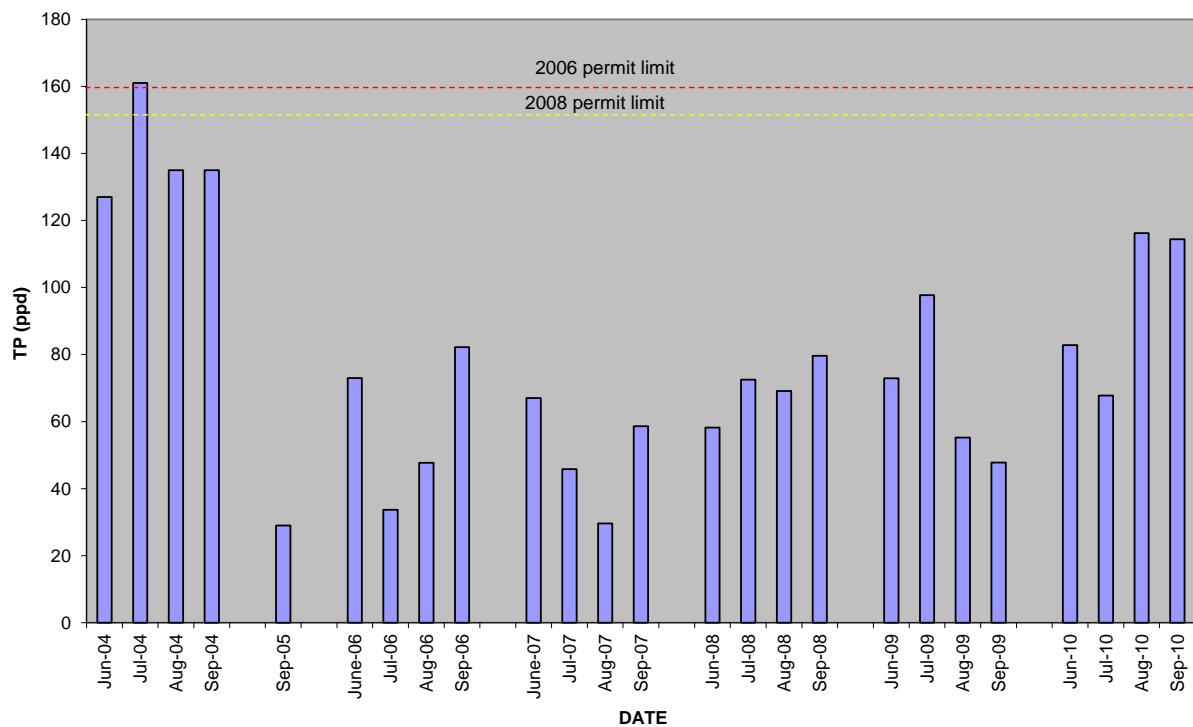


Figure 10. Mean summer monthly total phosphorus (TP) discharged (ppd, pounds per day) from Rumford Paper Company, 2004-2010



The MPDES permit issued in September 2005 and new Board of Environmental Protection orders issued February 2008 and June 2010 for Verso Paper Co. require that the summertime discharge of OP and TP not exceed 33 and 150 ppd respectively by June 1, 2008 and 28 and 130 ppd respectively by June 1, 2010. The discharge of OP and TP from Verso had been reduced by approximately 50% by 2007. While discharge of both have increased since, they are still within the permit limits (Figures 11 and 12).

Figure 11. Mean summer monthly ortho-phosphorus (OP) discharged (ppd, pounds per day) from Verso Paper Company, 2004-2010

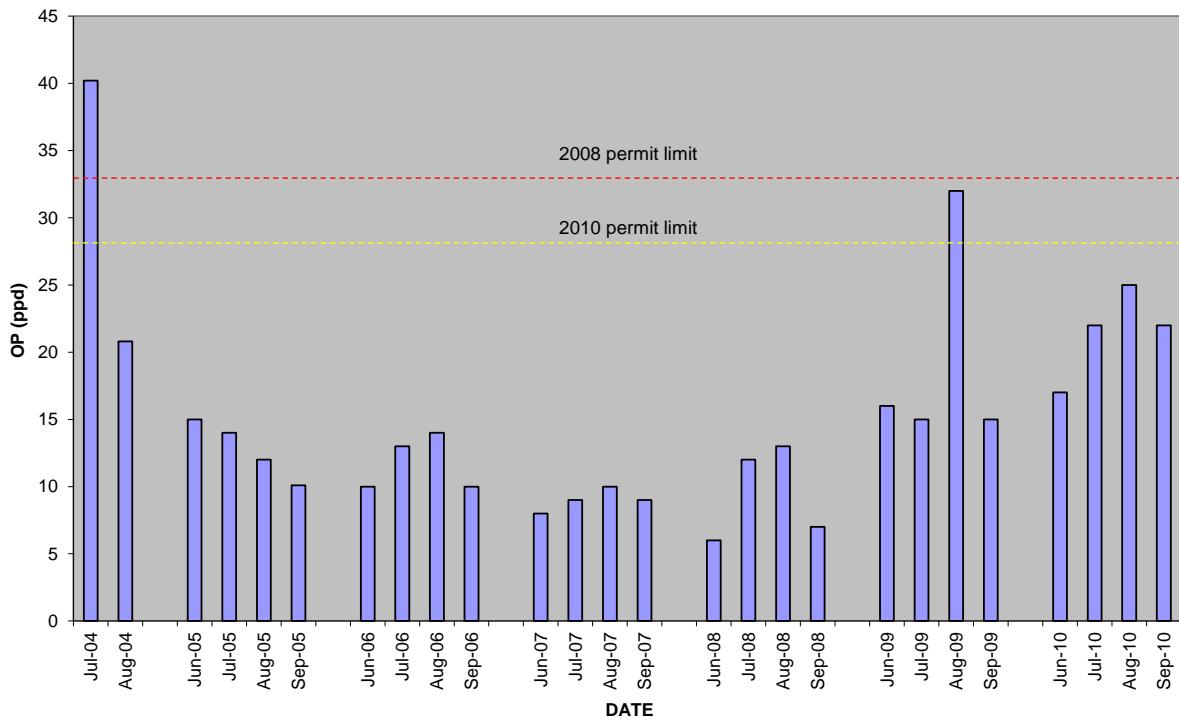
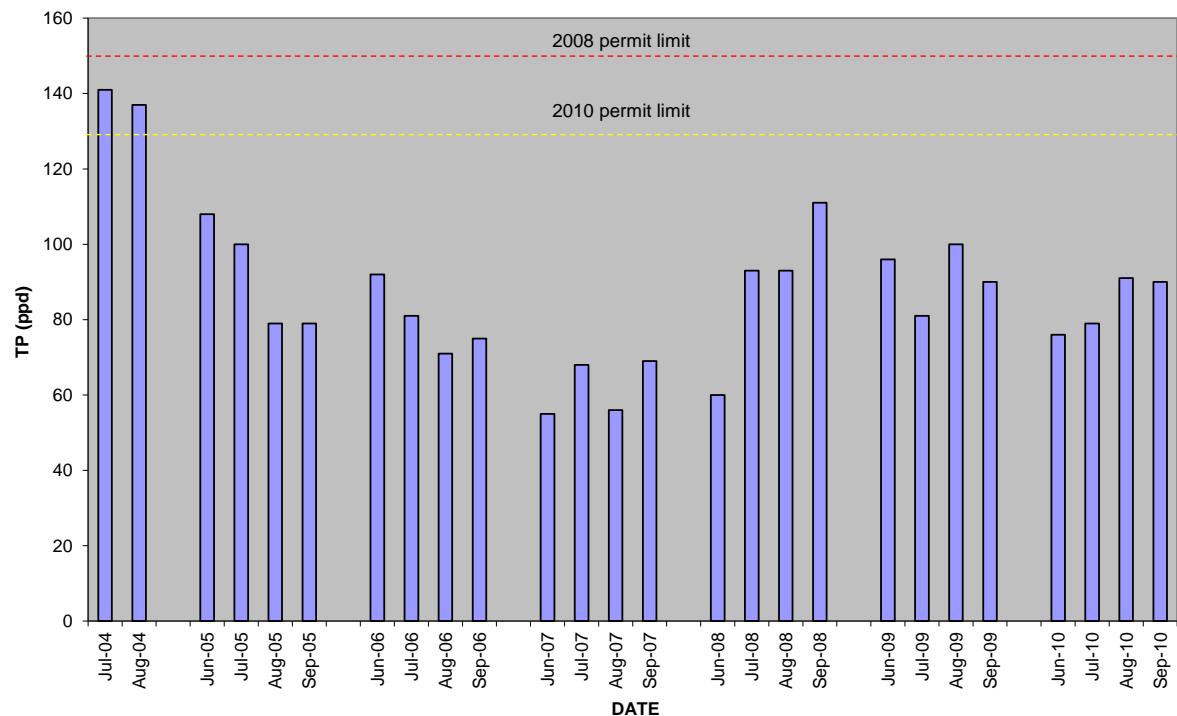


Figure 12. Mean summer monthly total phosphorus (TP) discharged (ppd, pounds per day) from Verso Paper Company, 2004-2010

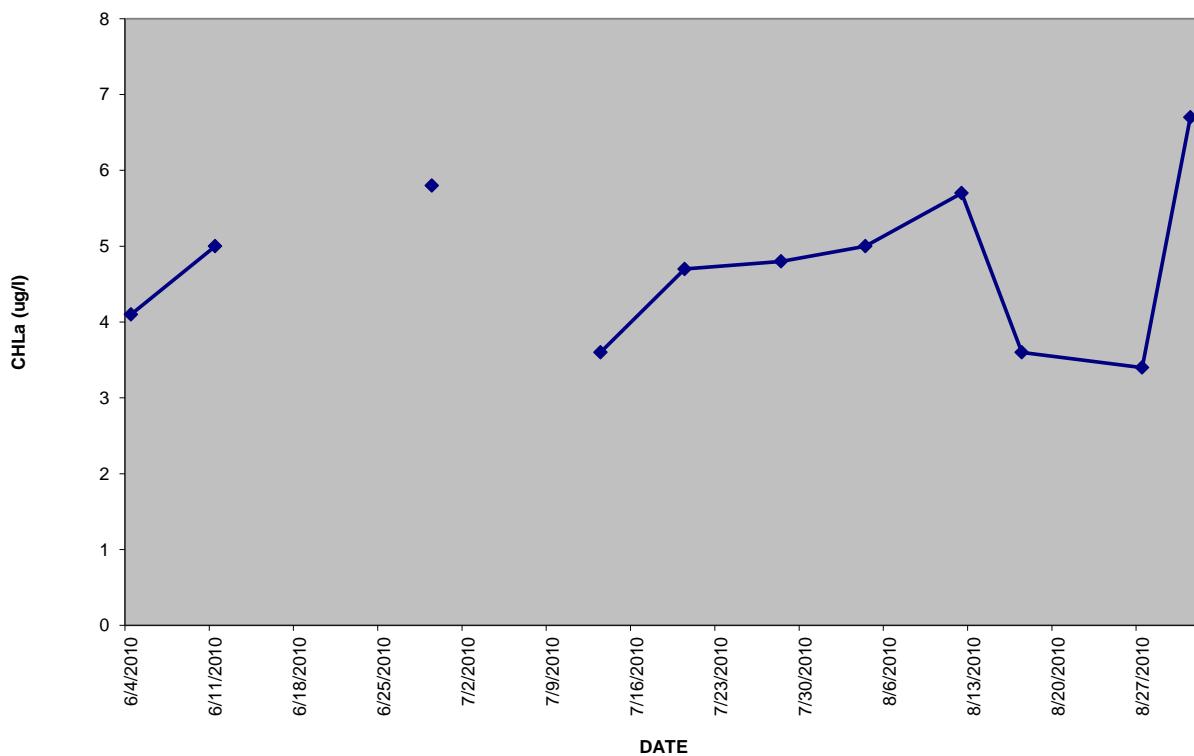


Chlorophyll-a (CHLa)

DEP Study

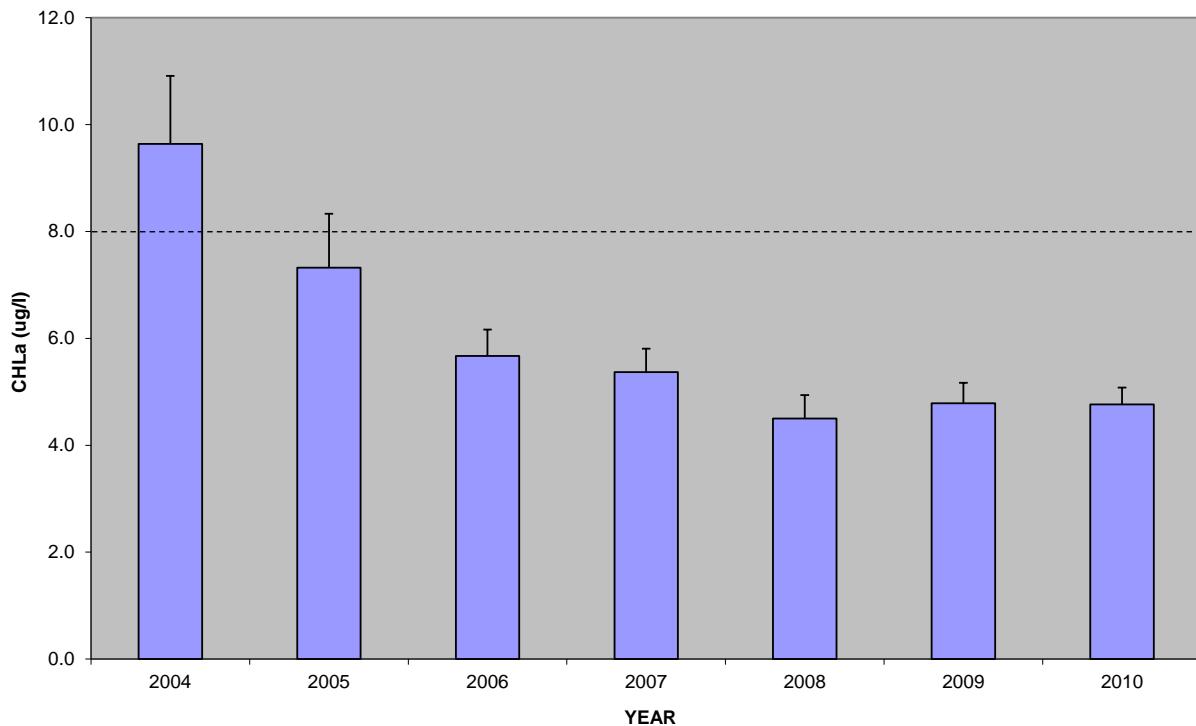
Uncorrected CHLa data are reported here for 2010 and all previous years. Reports from years prior to 2008 showed corrected chlorophyll a, which is determined by a different method that can result in a high bias. Uncorrected chlorophyll-a has been used by DEP's lakes program for many years. DEP sampling occurred at LN in June and IS thereafter. IS is approximately 1 mile downstream of LN and TP concentrations would not be expected to be different. The highest CHLa (6.7 ug/l) was on August 31; it was well below the threshold used for lakes (8 ug/l) for defining a phytoplanktonic algae bloom in lakes and the interim threshold (10 ug/l) proposed for GIP (Figure 13, Appendix 1). This peak CHLa was 6 days after the date of the peak TP, which was not much higher than it was for many other dates when CHLa was much lower. There was no observation of a bloom from the aerial flights on any sampling date.

Figure 13. Chlorophyll a (CHL a) concentrations in GIP at Lower Narrows (LN) and at Island Station (IS) 2010



In 2010 the mean summer CHLa concentration were similar to those of 2008 and 2009 (Figure 14). There appears to be a declining trend from 2004, when first measured, to 2008. There is no statistically significant difference in concentrations between any one year and the next.

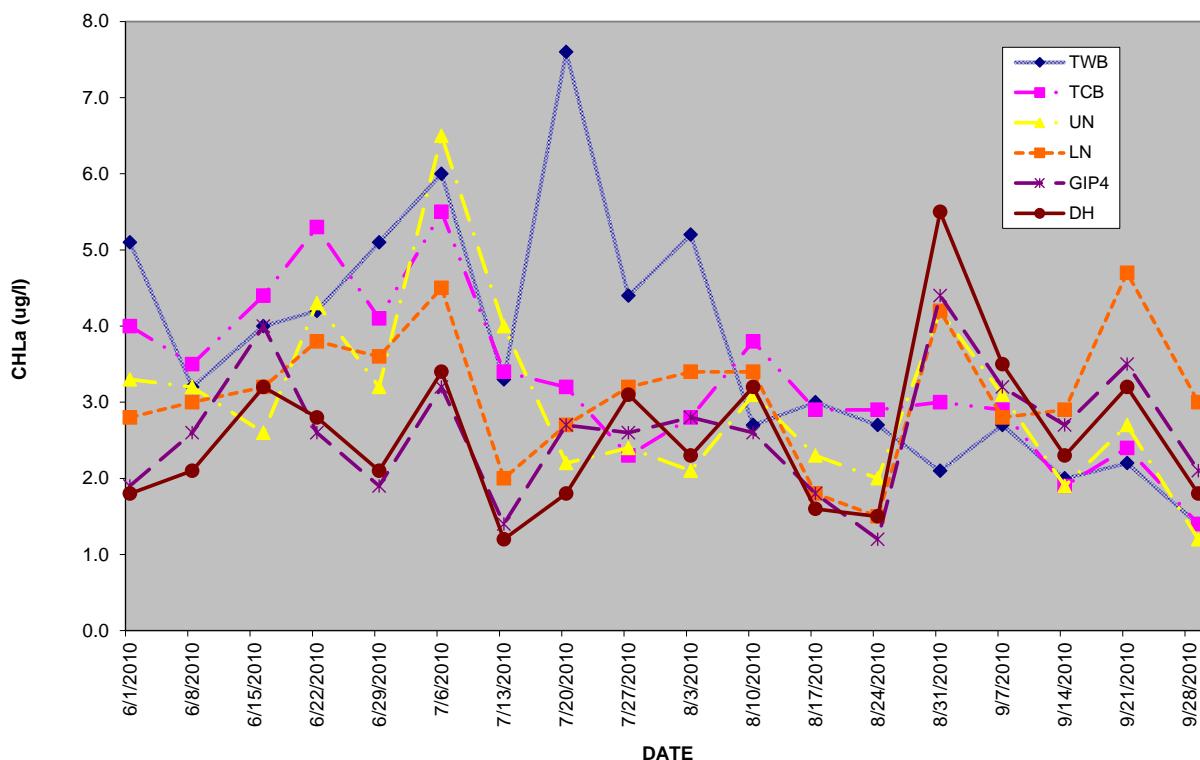
Figure 14. Mean summer chlorophyll a (CHLa) concentrations in GIP at Lower Narrows (LN) 2004-2009 and at Island Station (IS) 2010



Acheron/GIPOP study

Acheron weekly sampling at six stations in 2010 resulted in measurement of corrected CHLa with peaks varying by station (Figure 15, Appendix 2). Peak concentrations were usually highest in the upper stations (TWB, TCB, UN) early in the summer and in the lower stations (LN, GIP4, DH) later in the summer. That there was little correspondence between Acheron and DEP results is not unexpected given Acheron uses a different method and reported corrected CHLa while DEP reported uncorrected CHLa. No results exceeded the 8 ug/l threshold for algal blooms in lakes, which is consistent with aerial observations.

Figure 15. Chlorophyll a (CHLa) concentrations at 6 stations in GIP, 2010

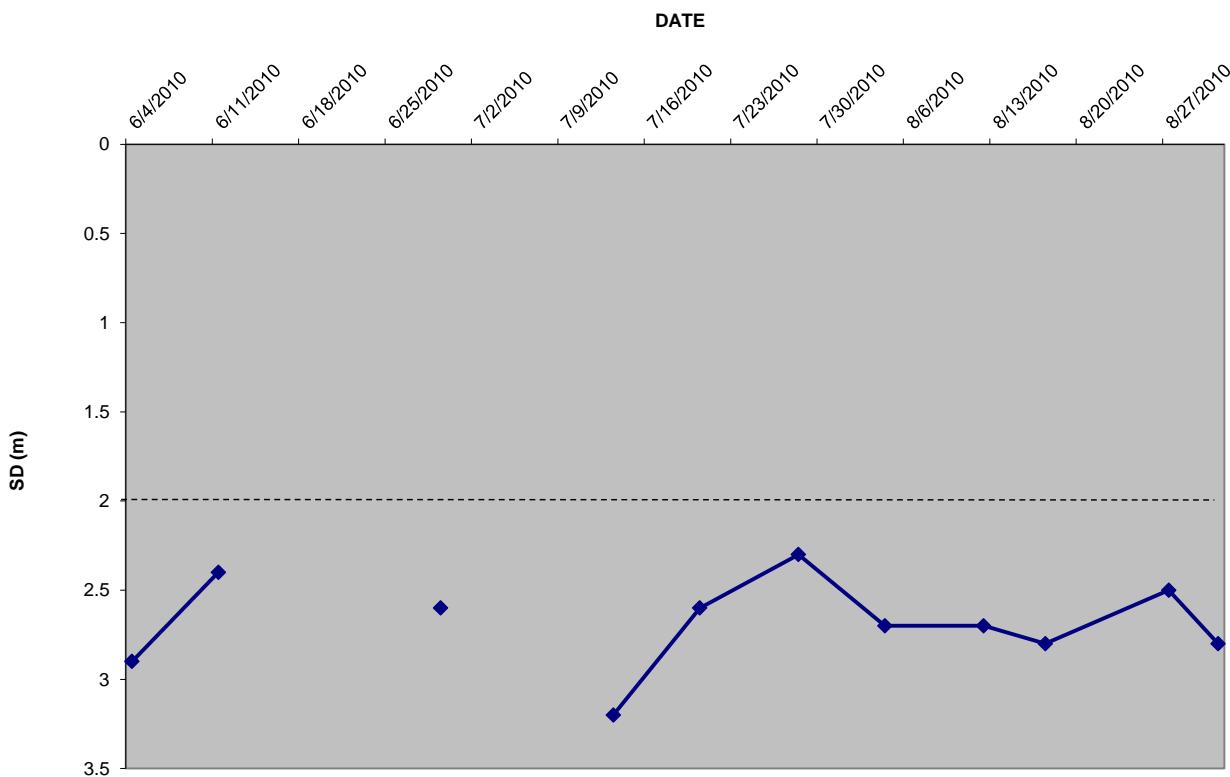


Secchi Disk Transparency (SD)

DEP Study

Secchi disk transparency is limited by high color as well as phytoplanktonic algae and solids. GIP is considered to have high (> 30 PCU) color (GIP = $40 \pm$ PCU) primarily due to upstream pulp mill discharges; therefore, the 2m threshold for the definition of an algae bloom in uncolored lakes does not define an algal bloom in GIP. Despite the high color, DEP weekly sampling in 2010 in June at LN and in July and August at IS documented no events when Secchi disk transparency was less than 2 m (meters) (Figure 16, Appendix 1). No sampling occurred during two weeks in June. On July 7 only DO and temperature was measured, and although there was no Secchi disk transparency measurement or CHLa sample, bloom conditions were not observed.

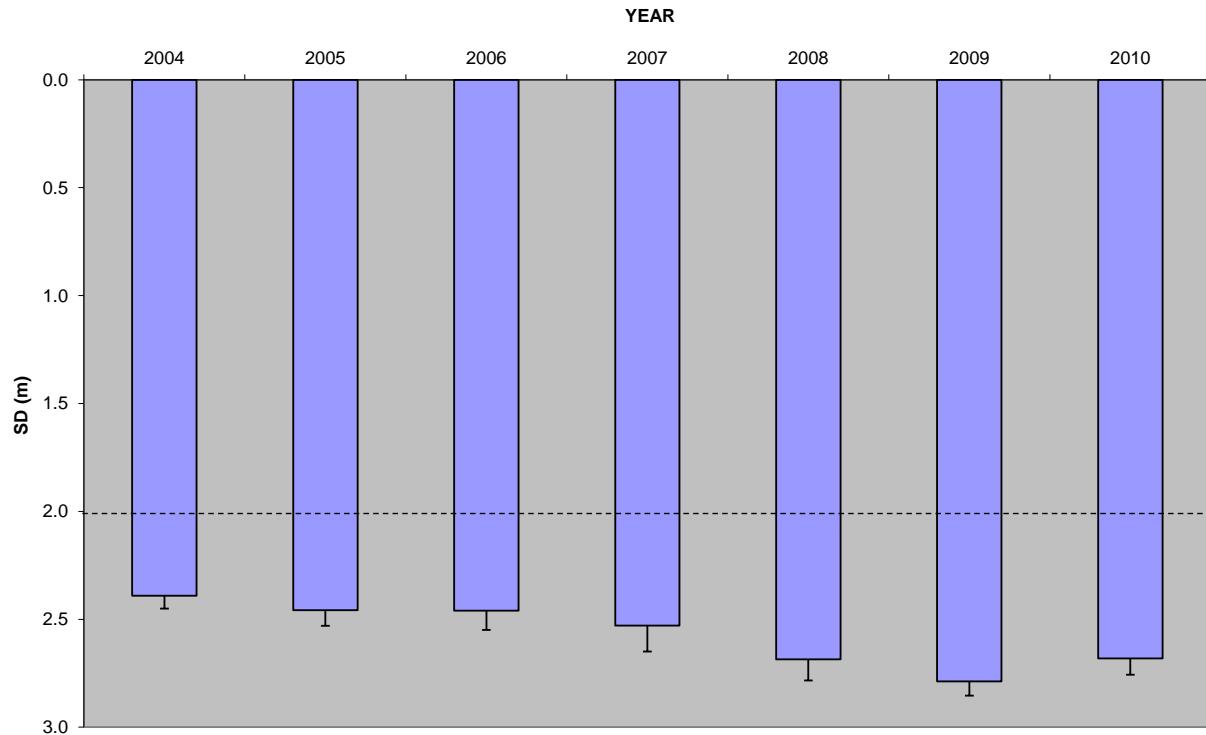
Figure 16. Secchi disk transparency (SD) in GIP at Lower Narrows (LN) and at Island Station (IS) 2010



Mean summer Secchi disk transparency was not significantly different than it has been since 2008 (Figure 17). While there has been no significant difference from one year to the next since the present monitoring strategy began in 2004, beginning in 2008 Secchi disk transparency has been significantly greater than that in 2004. While 2008 and 2009 were years of high river flow, 2010 was a low flow year. Increased Secchi disk transparency then may reflect reductions in discharges of TP and resulting CHLa since 2004.

Secchi disk transparency is not the most sensitive measure of algal biomass in GIP, and can be influenced by elevated color and silt that also reduce the Secchi disk transparency.

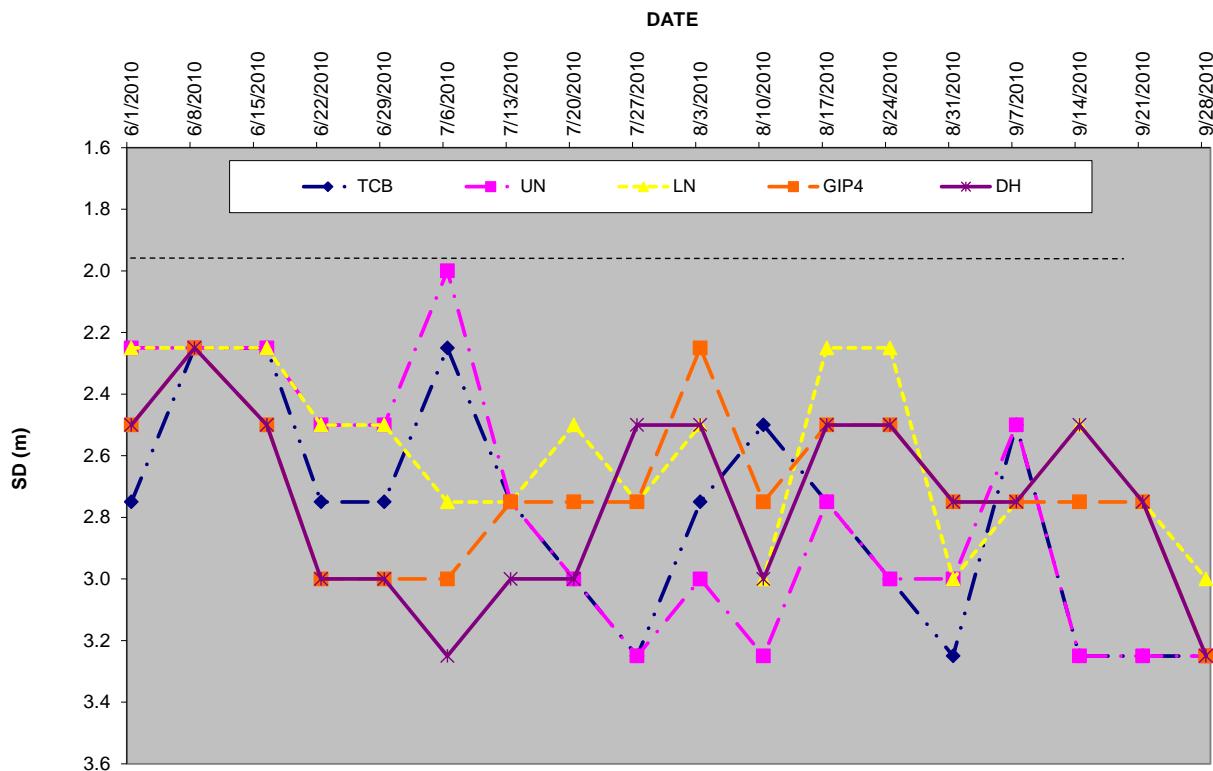
Figure 17. Mean summer Secchi disk (SD) transparency in GIP at Lower Narrows (LN) 2004-2009 and at Island Station (IS) 2010



Acheron/GIPOP study

Acheron sampling in 2010 documented that there were no dates when the Secchi disk transparency (SD) was below the threshold for blooms in lakes (2 m) (Figure 18, Appendix 2). The lowest SD (2 m) was measured at UN on July 6 which was the date of the highest CHLa concentration for that station. The lowest SD for other stations varied with sampling dates with no obvious pattern among stations. Mean SD transparency for the summer was similar for Acheron (2.6 m) and DEP (2.7 m) even at different sampling stations, with both varying by less than 1 m over the summer. SD for the two weeks in June, when there were no DEP measurements, was greater than 2 m.

Figure 18. Secchi disk (SD) transparency at 5 stations in GIP, 2010



3. TEMPERATURE AND DISSOLVED OXYGEN (DO)

In order to meet Maine's Water Quality Standards, particularly the designated uses which require that Maine waters are suitable for 'fishing' and 'provide habitat for fish and aquatic life' ... and ... 'support indigenous species of fish', with respect to measurement of DO Maine statute at 38 M.R.S.A. §464.4 specifies minimum (5.0 ppm) and monthly average (6.5 ppm at a temperature of 22°C or less) criteria for the Class C Androscoggin River. These criteria must be met everywhere all the time, except that in riverine impoundments, Maine statute at 38 M.R.S.A. §464.13, specifies the following:

Measurement of dissolved oxygen in riverine impoundments. Compliance with dissolved oxygen criteria in existing riverine impoundments must be measured as follows.

- A. Compliance with dissolved oxygen criteria may not be measured within 0.5 meters of the bottom of existing riverine impoundments.*
- B. Where mixing is inhibited due to thermal stratification in an existing riverine impoundment, compliance with numeric dissolved oxygen criteria may not be measured below the higher of:*

(1) The point of thermal stratification when such stratification occurs; or

(2) The point proposed by the Department as an alternative depth for a specific riverine impoundment based on all factors included in section 466, subsection 11-A and for which a use attainability analysis is conducted if required by the United States Environmental Protection Agency.

For purposes of this paragraph, "thermal stratification" means a change of temperature of at least one degree Celsius per meter of depth, causing water below this point in an impoundment to become isolated and not mix with water above this point in the impoundment.

C. Where mixing is inhibited due to natural topographical features in an existing riverine impoundment, compliance with numeric dissolved oxygen criteria may not be measured within that portion of the impoundment that is topographically isolated. Such natural topographic features may include, but not be limited to, natural deep holes or river bottom sills.

Notwithstanding the provisions of this subsection, dissolved oxygen concentrations in existing riverine impoundments must be sufficient to support existing and designated uses of these waters. For purposes of this subsection, "existing riverine impoundments" means all impoundments of rivers and streams in existence as of January 1, 2001 and not otherwise classified as GPA.

Thermal stratification typically results in three vertical zones or layers;

- 1) the epilimnion (top layer which is relatively homothermous),
- 2) the metalimnion or thermocline (middle layer of thermal transition); and
- 3) the hypolimnion (bottom layer which is relatively homothermous).

The thermocline is defined as the zone where the temperature decreases at least one degree Celsius per meter of depth. Typically this zone is several meters thick, and therefore, to determine compliance with

the statute in thermally stratified riverine impoundments, it is necessary to choose one depth within this zone as the ‘point’ of compliance or point of thermal stratification (POTS).

Although the Water Quality Certification issued in 2005 to Florida Power and Light for operation of the Gulf Island Hydropower project cited topographic isolation at 60 feet (18.3 m) in GIP, monitoring data collected since then show that thermocline, and hence inhibition of mixing, often migrates weekly, daily, and sometimes hourly above and below this depth. These data document that although topographic isolation plays less of a role under some conditions, thermal stratification is usually the dominant factor controlling mixing.

Nevertheless, as defined in statute and in consideration of the last paragraph of the statute as the overall controlling section, DO levels must be sufficient to support designated and existing uses of the waterbody, which requires the protection of a cold water zone providing habitat for indigenous species of fish, i.e. some amount of water cold enough with enough oxygen to support cold water fish. After consultation with the Department of Inland Fisheries and Wildlife, the Commissioner of DEP stated in a letter of January 23, 2007 to the Gulf Island Pond Partnership (GIPOP Partnership), that for thermally stratified impoundments, “the Department will consider the point of thermal stratification to be the bottom of the first meter segment in the thermal profiling data where the temperature gradient is one degree Celsius or greater per meter” i.e. within the thermocline. The intention of this clarification is that “this approach is designed to ensure the existence of a refuge where cold water species of fish can retreat to during warm weather that will provide the statutory DO level for at least one meter of depth, and is consistent with both the statute’s clear language and purpose”. Since then, new information has demonstrated that suitable temperatures for a refuge for cold water fish ($T \leq 24^{\circ}\text{C}$, EPA Ambient Water Quality Criterion for short-term maximum for survival) do not always exist in the first meter of the thermocline. Consequently, when suitable temperatures ($T \leq 24^{\circ}\text{C}$) and DO ($\geq 5 \text{ ppm}$) exist for at least a one meter layer anywhere from the top of the first meter segment of the thermocline and deeper, DO concentrations for that date and time will be considered adequate to meet the minimum DO water quality criterion of 5 ppm. For unstratified waters, DO concentrations must attain the minimum criterion at all depths. However, for either stratified or unstratified waters, the bottom most reading is discounted due to the difficulty in knowing if it is in the soft sediment or within 0.5 m of the bottom where DO may not be measured according to statute.

Point of Thermal Stratification (POTS)

DEP’s experience with lakes reveals that the bottom of the first meter segment in the thermal profiling data may not always guarantee at least one meter of cold well-oxygenated water. In strongly stratified waters, temperature can change by more than one degree Celsius within a depth increment as little as $\sim 0.2 \text{ m}$ ($< 1 \text{ foot}$). As a consequence, there may be only a fraction of a meter of suitable habitat for cold water fish, which is not enough to support the population as required by statute. In these cases, it would be necessary to meet the DO requirements to a greater depth. In any case it would be important to measure at depth increments of less than 1 m within the thermocline.

The continuous monitor data collected by the GIPOP Partnership had been at the 5, 20, 35, and 50 foot depths near Gulf Island Dam and at a single depth near the bottom of the Deep Hole until 2008, insufficient to determine the POTS. Beginning in 2008, at the request of DEP, measurements have been made at 1 m depth increments every 2 hours at the Deep Hole only, which provide better data but are still less than ideal to determine the POTS and to assess whether the minimum required habitat within the

thermocline has been provided. The weekly monitoring by Acheron has also been collected at 1 m depth increments. In 2009, DEP was to collect data at more depths within the thermocline in order to determine a more accurate determination of the POTS, but high flows precluded strong stratification and the monitoring was not conducted. In 2010 measurements of temperature and DO were made at smaller intervals within the thermocline at Island Station on July 7, 2010. The data show that the temperature decreased by $>1^{\circ}\text{C}$ from 18 m to 18.3 m, which demonstrates the importance of measurements at smaller depth increments within the thermocline. Nevertheless, the data show that calculating the rolling monthly average DO to 19 m assures the presence of 1 meter of habitat for this date, although this would not necessarily be the case for all dates. Measurements in 2011 should be made at 0.2 m increments within the thermocline.

DEP Study

In 2010, DEP measured temperature and DO vertical profiles at one meter (m) increments weekly at Lower Narrows (LN) in June and at Island Station (IS) in July and August after the new oxygenation injection point began operation at Lower Narrows. Maximum depth at IS was approximately 24 m, and varied weekly by 1-2 m due to storm events and drawdown for hydropower generation at the Gulf Island Dam. The POTS varied from 16 to 23 m throughout the summer when thermally stratified but the pond was completely mixed top to bottom on other days. The minimum DO criterion of 5 ppm was met for 7 of 9 sampling events after the installation of the new diffuser at LN, and there were excursions below the minimum DO criterion of 5 mg/l during only 2 of 9 sampling events (Figures 19-20, Appendix 1). Given that sampling events are assumed to be representative of all the days between the dates, and assuming a linear transition in DO levels between adjacent weekly sampling dates, then it appears that there was approximately 78% of the sampling period when DO met the minimum criterion and 22% of the sampling period when DO was lower than the minimum criterion at IS.

Figure 19. Temperature (T) and dissolved oxygen (DO) levels at Island Station (IS), GIP, July 7, 2010 (POTS = point of thermal stratification)

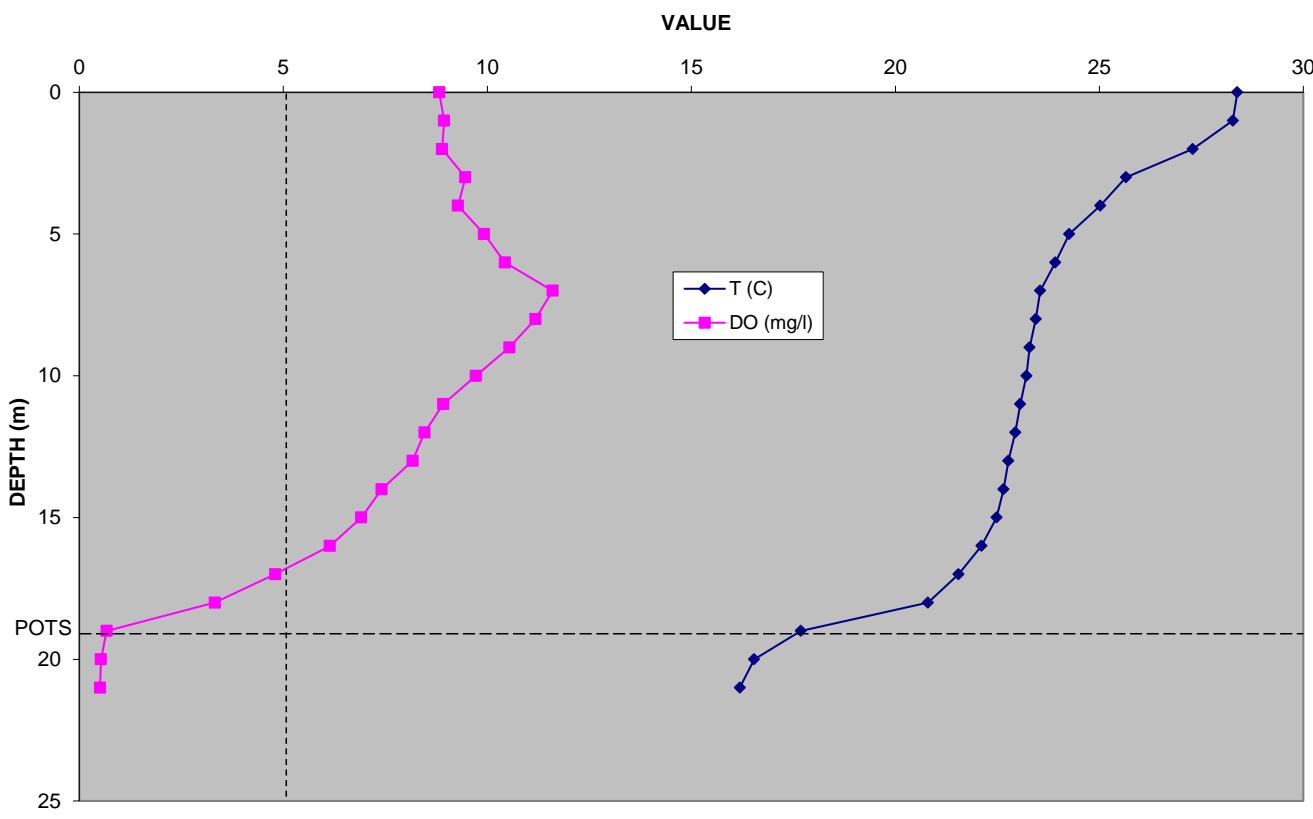
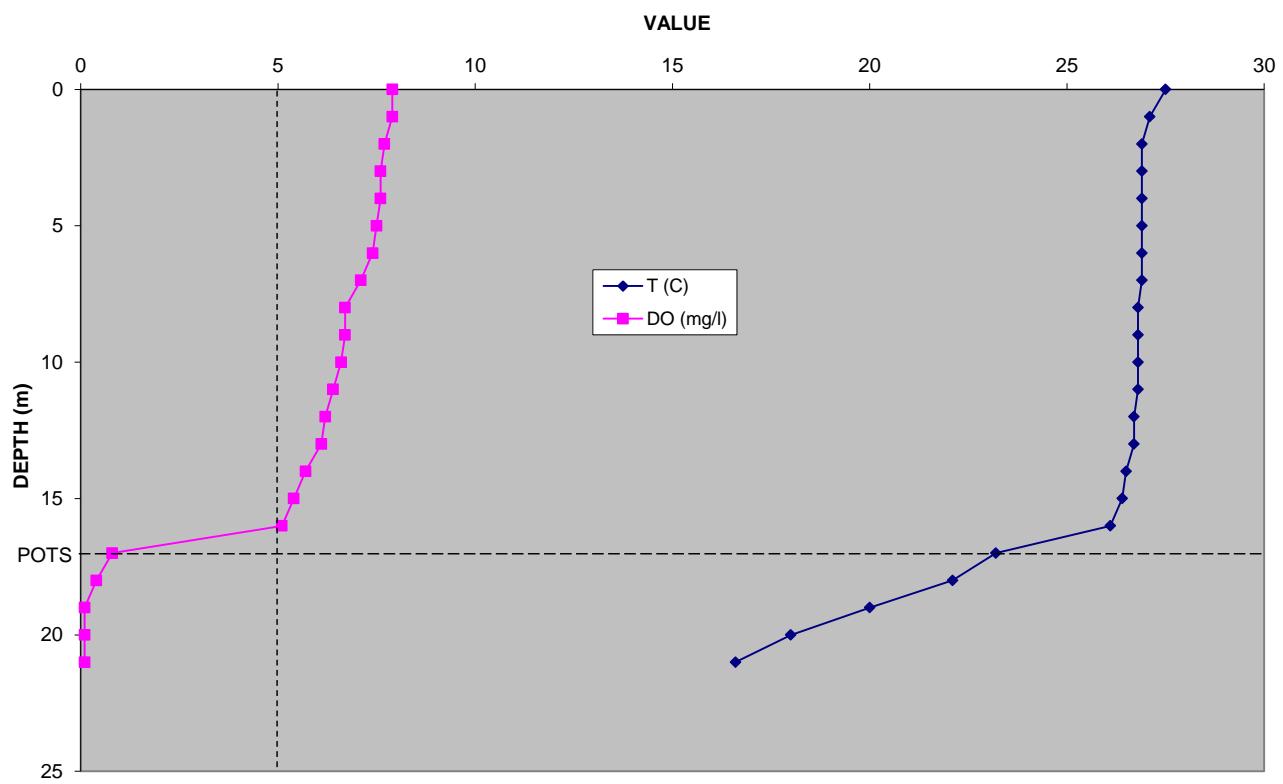
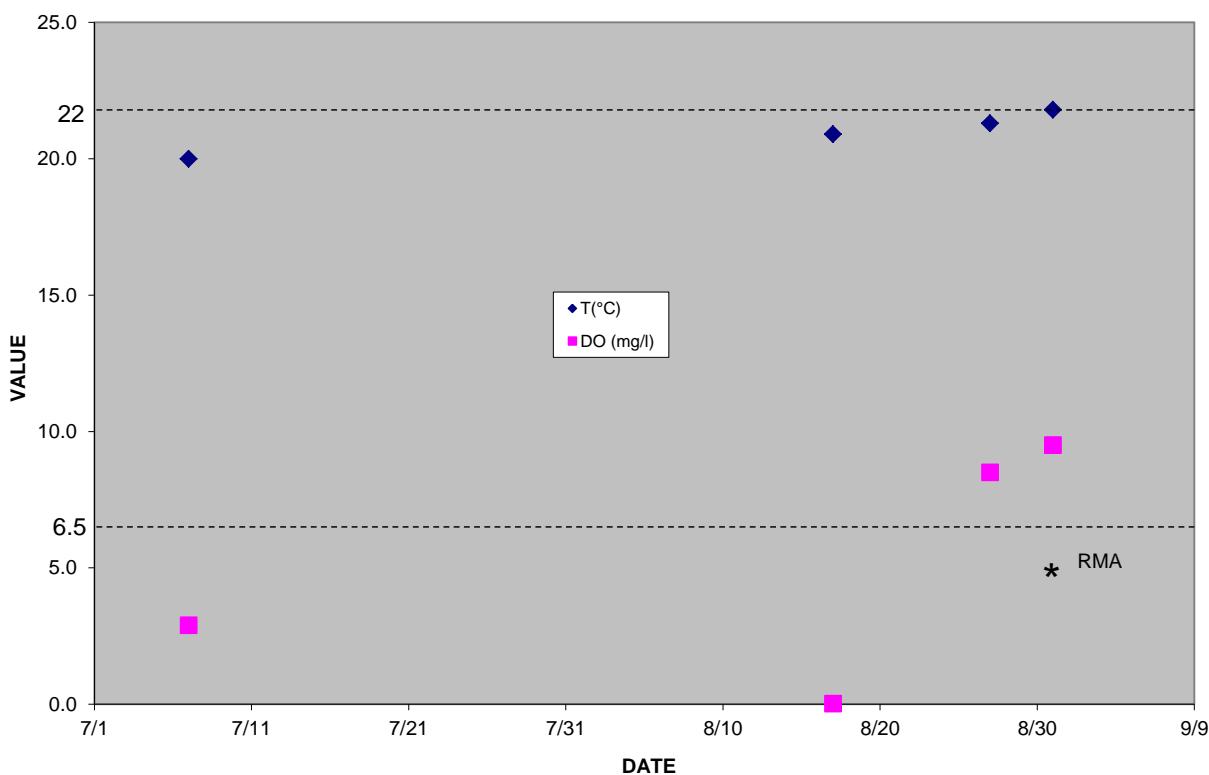


Figure 20. Temperature (T) and dissolved oxygen (DO) levels at Island Station (IS), GIP, July 20, 2010 (POTS = point of thermal stratification)



The rolling monthly average DO criterion of 6.5 mg/l applies when temperature is 22°C or below (38 MRSA § 465 (4)(B)). The rolling monthly average (RMA) DO was calculated in two steps. First the mean DO concentration was calculated for each sampling day for all depths where the temperature was equal to or less than 22°C down to the POTS or to the penultimate reading above the bottom in cases where there was no thermal stratification. Second, the mean DO for four previous weeks where there was some water where temperature was equal to or less than 22°C was calculated as a rolling monthly average. Because this station was sampled from a float plane that was difficult to hold precisely over the deepest spot in the wind, sampling often occurred in shallower water where temperature was greater than 22°C to the bottom. Consequently, there were only four weeks of data with water equal to or less than 22°C. The RMA was below the 6.5 ppm monthly average criterion for that 28 day period (Figure 21). Use of an anchored buoy in 2011 will allow data to be collected at the deepest spot at this station.

Figure 21. Daily average temperature (T) and dissolved oxygen (DO) for the four sampling periods where water $T \leq 22^{\circ}\text{C}$ and rolling monthly average (RMA*) DO at Island Station, Gulf Island Pond, 2010



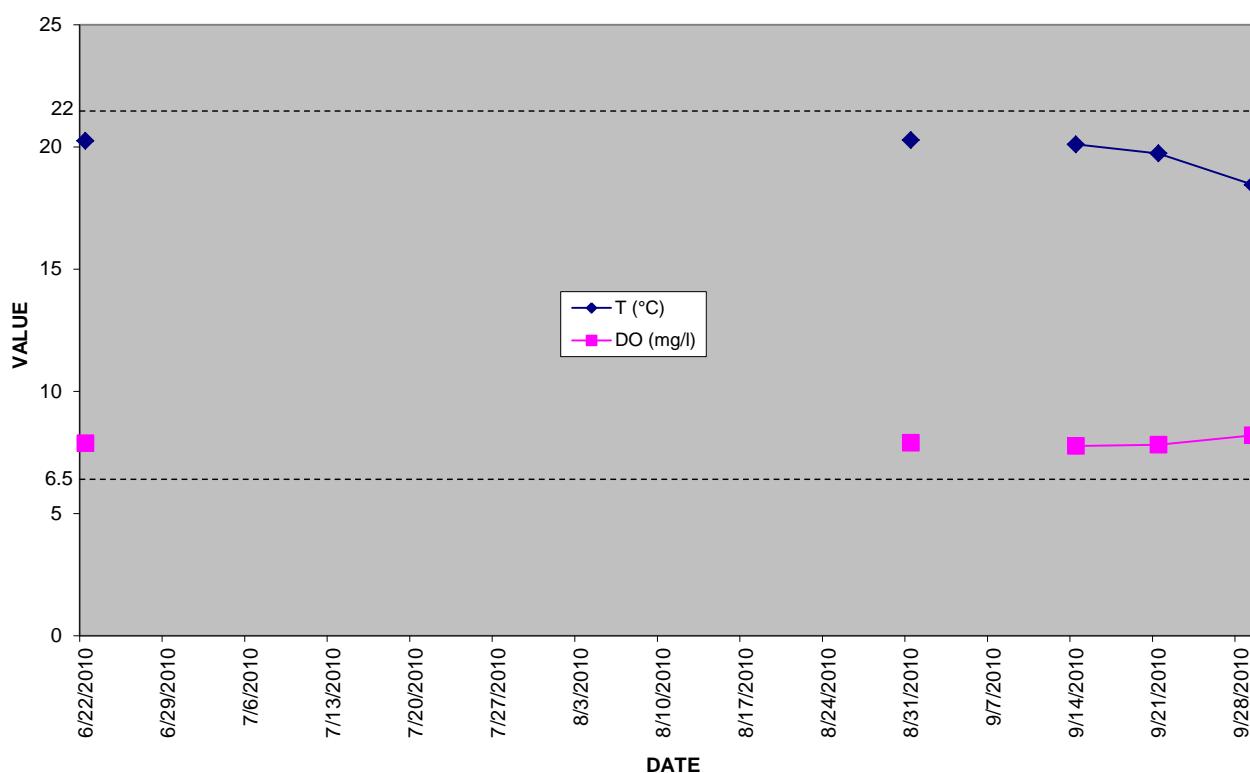
Acheron/GIPOP study

Weekly temperature and DO profile measurements made at five GIP stations by Acheron are available for viewing in paper copy or on CD at DEP or on the web at <http://www.maine.gov/dep/water/wd/gip/>. Measurements were taken in the morning for 18 weeks. The bottom reading is not counted as it was unknown if it was within 0.5 m of the bottom where by statute DO will not be measured for attainment of the DO criteria. Examination of the data reveals the findings that following, by stations.

Turner Center Bridge (TCB)

TCB is too shallow with too much current to stratify thermally. DO concentrations were greater than the 5.0 mg/l minimum criterion for all sampling dates (Appendix 3). Temperatures were above 22°C for many sampling dates, and consequently the rolling monthly average (RMA) DO could be calculated for only 5 dates. The RMA was above the 6.5 mg/l monthly average criterion for all 5 sampling dates (Figure 22).

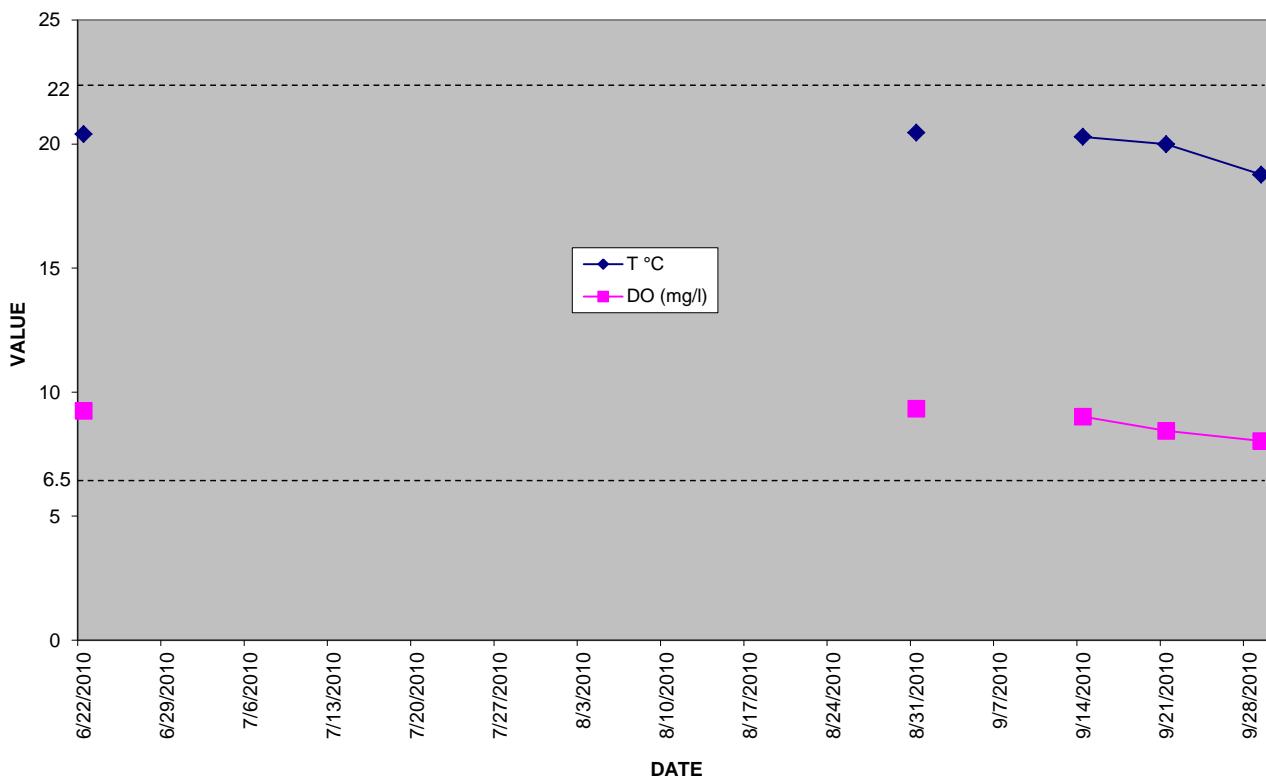
Figure 22. Daily average temperature (T) and rolling monthly average dissolved oxygen (DO) at Turner Center Bridge (TCB), Gulf Island Pond, at dates and from depths where $T \leq 22^{\circ}\text{C}$ to the penultimate depth, 2010



Upper Narrows (UN)

The sampling station at UN was moved from below the diffuser at UN to above the diffuser on July 1. At UN there were no sampling dates when there was thermal stratification or when DO was in non-attainment of the minimum DO criterion of 5 mg/l (Appendix 3). Temperatures were above 22°C for many sampling dates, and consequently the rolling monthly average (RMA) DO could be calculated for only 5 dates. The RMA was above the 6.5 mg/l monthly average criterion for all 5 sampling dates (Figure 23). The sampling station was above the diffuser during this period.

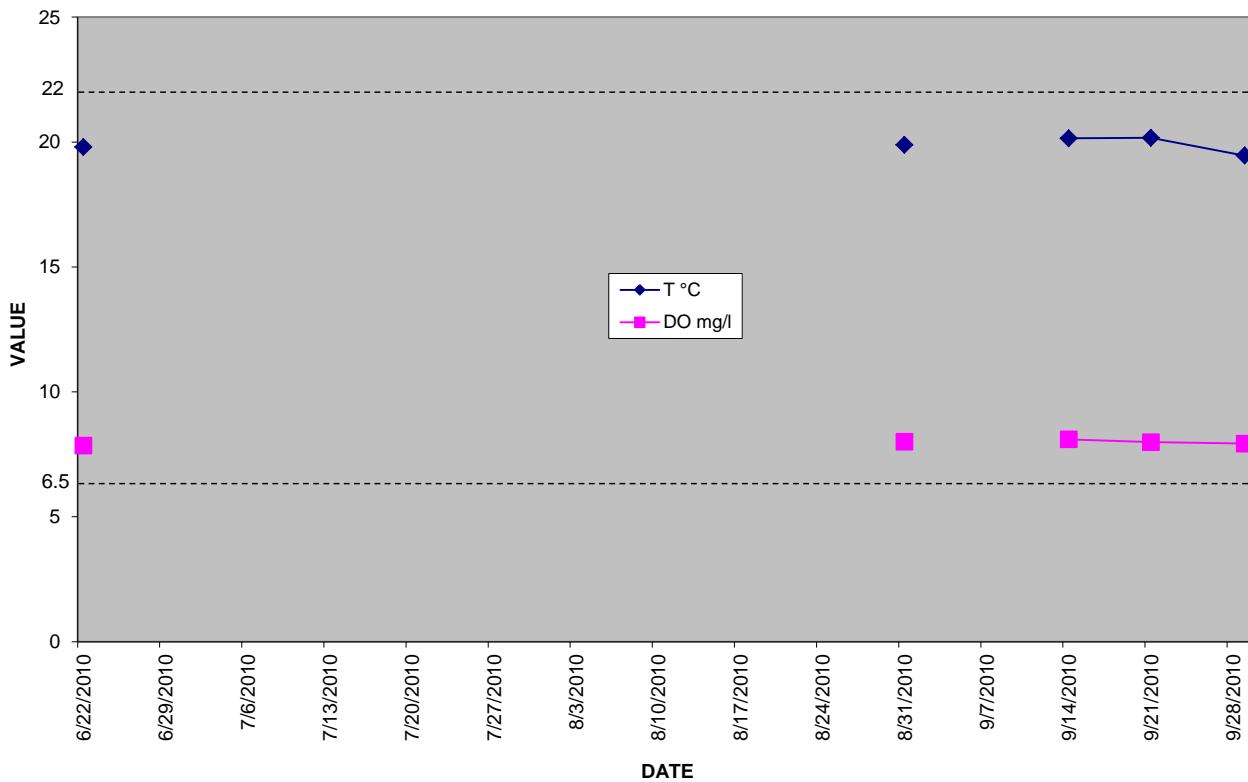
Figure 23. Daily average temperature (T) and rolling monthly average dissolved oxygen (DO) at Upper Narrows (UN), Gulf Island Pond, at dates and from depths where $T \leq 22^{\circ}\text{C}$ to the penultimate depth, 2010



Lower Narrows (LN)

Sampling at the original LN station showed DO below the minimum criterion of 5 mg/l on 1 of 5 sampling dates in the deeper part of the pond in June, before the new oxygenation diffuser at LN went on line July 1. The sampling station was moved further upstream after July 1 to be above the new LN diffuser. The new LN station is closer to the diffuser at UN and shallower than the original LN station; consequently, there was no thermal stratification or non-attainment of the minimum DO of 5 mg/l on any dates after July 1. Temperatures were above 22°C for many sampling dates, and consequently the rolling monthly average (RMA) DO could be calculated for only 5 dates. The RMA was above the 6.5 mg/l monthly average criterion for all 5 sampling dates (Figure 24).

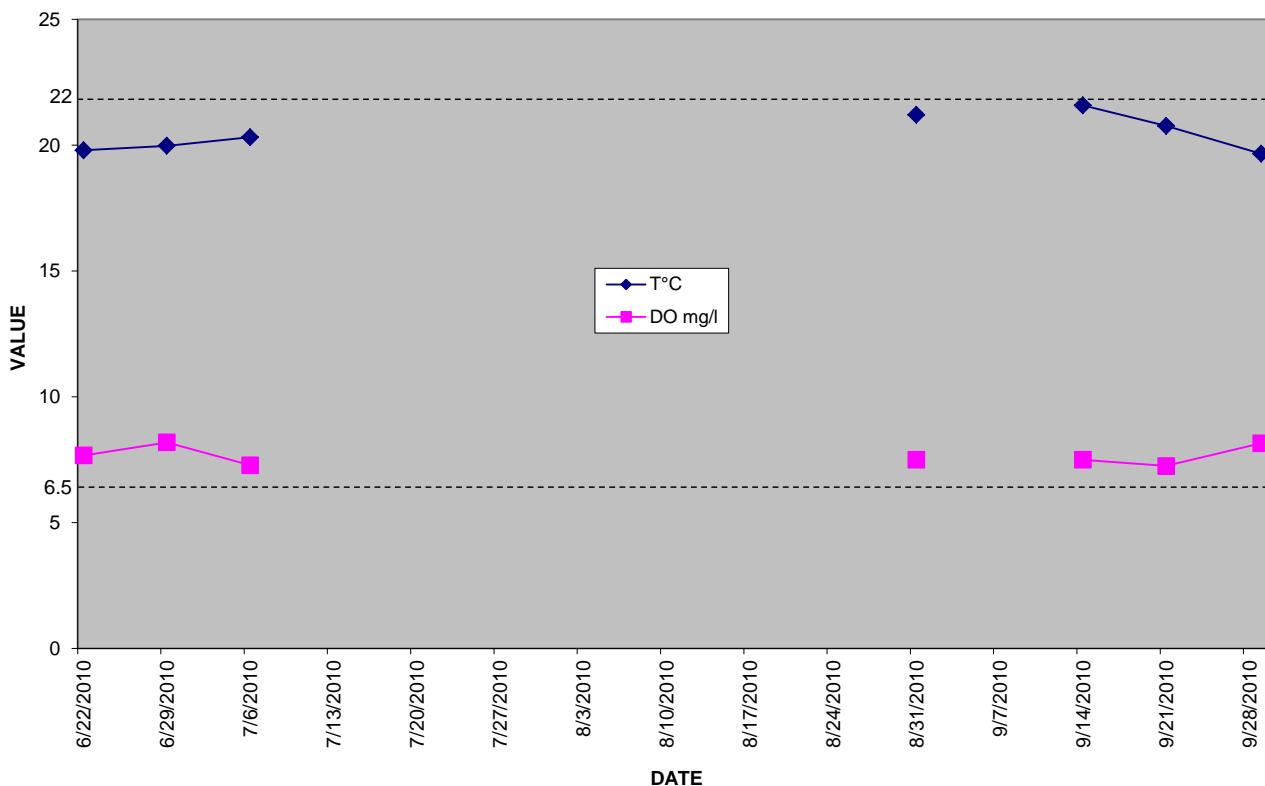
Figure 24. Daily average temperature (T) and rolling monthly average dissolved oxygen (DO) at Lower Narrows (LN), Gulf Island Pond, at dates and from depths where $T \leq 22^{\circ}\text{C}$ to the bottom of the first meter of the thermocline or the penultimate depth, 2010



GIP 4

At GIP 4, DO was in attainment of the minimum DO criterion of 5 mg/l on 14 of 18 sampling dates representing 78% of the sampling period, but there were 4 of 18 sampling dates, representing about 22% of the sampling period, when there was non-attainment of the criterion in the deeper part of the Pond. Temperatures were above 22°C for many sampling dates, and consequently the rolling monthly average (RMA) DO could be calculated for only 7 dates, 3 of which represented conditions prior to installation of the new diffuser upstream at Lower Narrows. The RMA was above the 6.5 mg/l monthly average criterion for all 7 dates representing the entire sampling period (Figure 25).

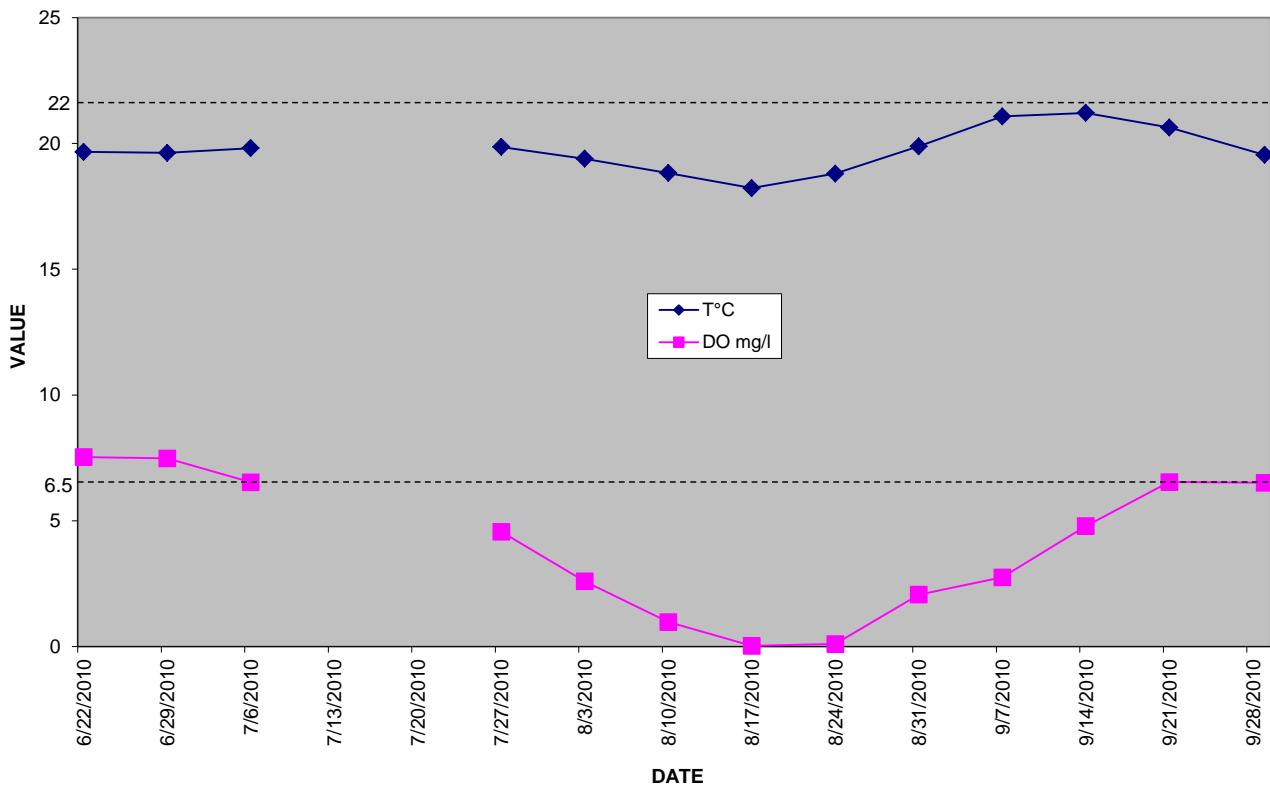
Figure 25. Daily average temperature (T) and rolling monthly average dissolved oxygen (DO) at GIP4, Gulf Island Pond, at dates and from depths where $T \leq 22^{\circ}\text{C}$ to the bottom of the first meter of the thermocline or penultimate depth, 2010



Deep Hole (DH)

At the DH station, DO has improved greatly since 2004, when DO attained the minimum DO criterion of 5 ppm for only 3 of 13 sampling dates representing 23% of the sampling period, and was below the minimum criterion for 10 of 13 sampling dates representing 77% of the sampling period in a band of 1 to 4 m thick (4 sampling dates extending to 3 m above the top of the thermocline). In 2010, DO was in attainment of the minimum DO criterion of 5 mg/l on 13 of 18 sampling dates representing about 72% of the sampling period, and there were only 5 of 18 sampling dates representing about 28% of the sampling period when there was non-attainment in a band of 1 to 3 m thick (1 sampling date extending to 1 m above the top of the thermocline) (Appendix 3). Temperatures above the point of thermal stratification were greater than 22°C for two sampling dates, and consequently the rolling monthly average (RMA) DO was calculated for only 13 dates, 3 of which represented conditions prior to installation of the new diffuser upstream at Lower Narrows. The RMA DO was below the 6.5 mg/l monthly average criterion for 8 of all 13 sampling dates (62%) when it could be calculated and 8 of 10 sampling dates, representing 80% of the sampling period, after the new diffuser began operation (Figure 26). The difference in RMA DO between this station and upstream stations is that this station is deeper and has more dates with water equal to or less than 22°C, allowing calculation of RMA DO for more sampling dates than upstream stations.

Figure 26. Daily average temperature (T) and rolling monthly average dissolved oxygen (DO) at the Deep Hole (DH), Gulf Island Pond, at dates and from depths where $T \leq 22^{\circ}\text{C}$ to the bottom of the first meter of the thermocline or penultimate depth, 2010



CONTINUOUS TEMPERATURE AND DISSOLVED OXYGEN (DO) DATA

The continuous monitoring data, gathered and reported by Water Monitoring Services, Inc. on behalf of the GIPOP, provide additional information about temperature and DO. Beginning in 2008, DEP approved a modification of the continuous monitoring study plan from that of previous years. The station 0.2 miles above the dam was eliminated. Temperature and DO monitoring was increased at the Deep Hole (DH) station, from monitoring every hour at one fixed depth as it was in prior years, to monitoring in a profile from top to bottom at one meter increments every two hours during the summer. Temperature and DO at Turner (Center) Bridge (TCB = TCB) has been monitored every hour during the summer near mid depth as in previous years.

At TCB, river temperature varied throughout the summer (Figure 27), but minimum and monthly average DO were greater than the 5.0 mg/l minimum and 6.5 mg/l monthly average criteria respectively (Figure 28 Appendix 4) for all days monitored regardless of temperature

**Figure 27. Daily maximum, mean, and minimum temperature (T) concentrations at Turner Center Bridge (TCB), Gulf Island Pond, 2010
(data collected by Water Monitoring Services on behalf of GIPOP)**

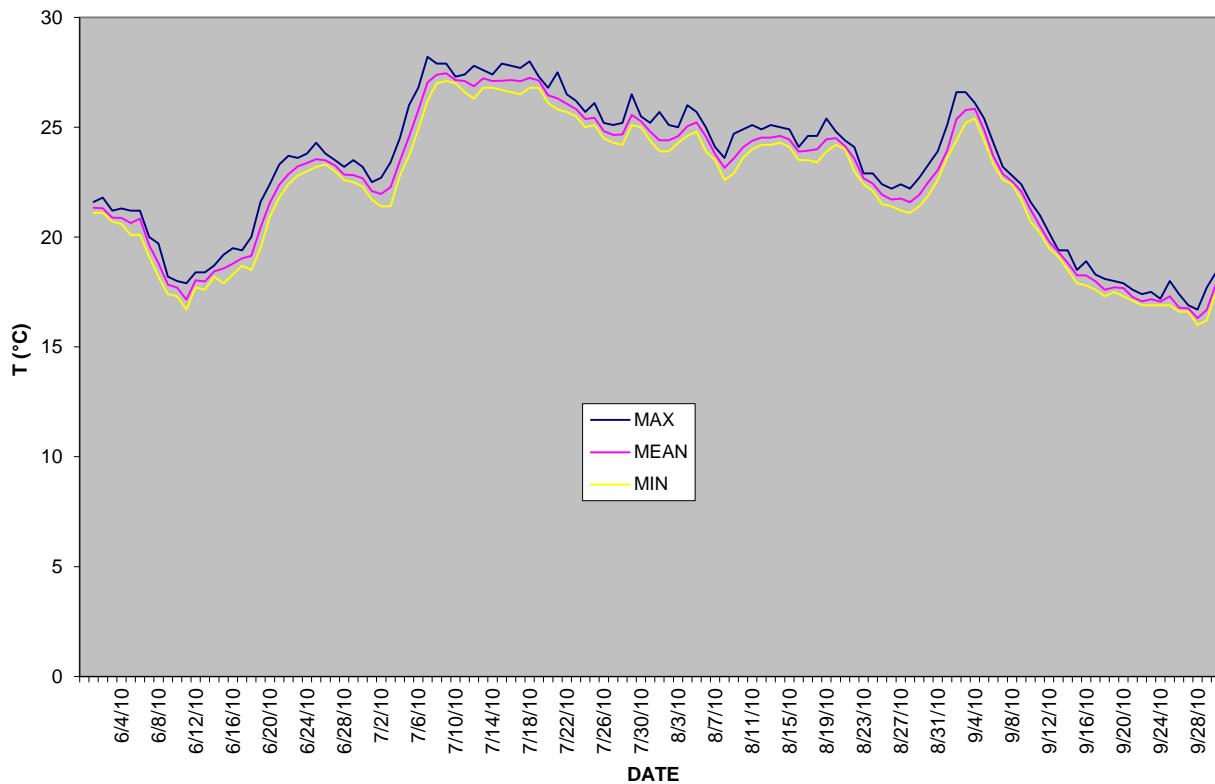
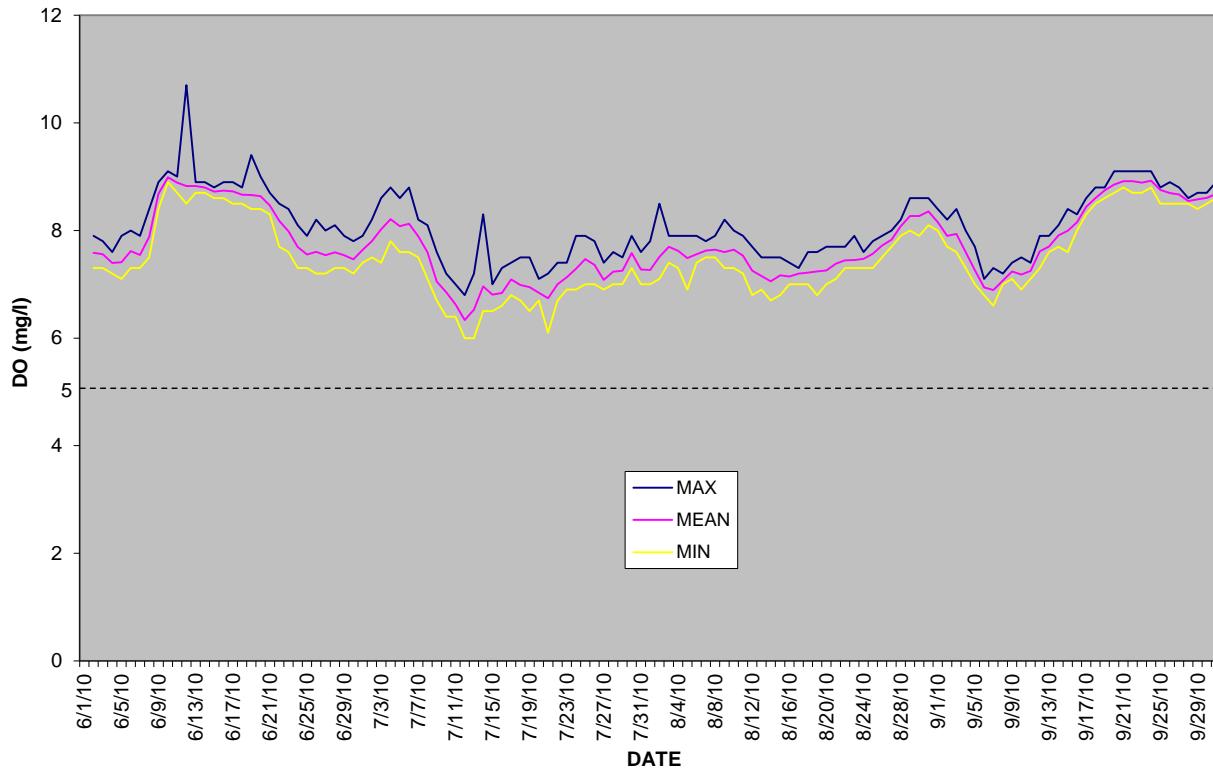
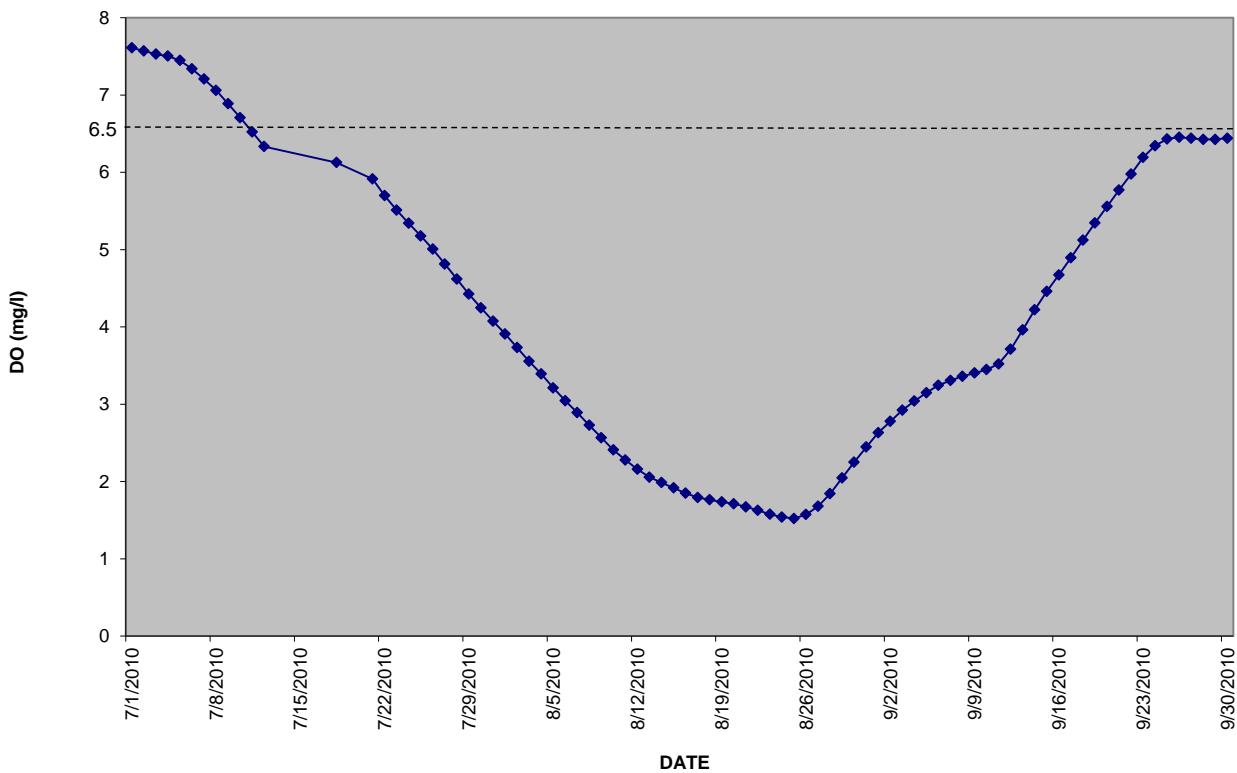


Figure 28. Daily maximum, mean, and minimum dissolved oxygen (DO) concentrations at Turner Center Bridge (TCB), Gulf Island Pond, 2010 (data collected by Water Monitoring Services on behalf of GIPOP)



At the DH, DO was below the 5.0 mg/l minimum criterion for at least one measurement for 53% of the days (no data June 6) and for 3% of the total number of measurements at applicable depths during the June 1 to September 30 sampling period. At the DH, DO was below the 60% saturation minimum criterion for at least one measurement for 60% of the days (no data June 6) and for 3% of the total number of measurements at applicable depths during the June 1 to September 30 sampling period. Of the 3% of the total measurements that were below the minimum criteria, most were usually restricted to a narrow (1-3 m) band near or in the thermocline. The rolling monthly average (RMA), in the water from the depths where the temperature was 22°C or less down to the bottom of the first meter in the thermocline or to one meter from the bottom of the impoundment when there was no thermal stratification, was less than the 6.5 mg/l monthly average criterion for 74 of the 85 days (87%) where it could be calculated (Figure 29). From the total 121 days of measurements, a RMA could not be calculated for the first 29 days. Of the 92 remaining days, there were 7 days, where the temperatures were greater than 22°C above the bottom of the first meter of the thermocline, when no RMA could be calculated.

Figure 29. Rolling monthly average (RMA) dissolved oxygen (DO) concentrations from depths where temperature is 22 C or less to the bottom of the first meter of the thermocline or 1 m from the bottom at the Deep Hole, GIP, 2010



As demonstrated by the 2010 monitoring data, daytime air temperatures and exposure to summer sunlight can occasionally result in a large temperature gradient in the upper portion of the pond that is ephemeral and not considered significant thermal stratification. For example there were several readings throughout the summer where suddenly much warmer weather resulted in a sudden increase in temperature of the top 1-3 meters of the pond by more than 1° C above the next deeper layer, but temperature and DO were virtually unchanged from there down to much deeper waters, where a temperature gradient of >1°C/m defines the POTS. It has been the DEP's conclusion that during times like these, mixing is not inhibited at the shallower zone of large temperature gradient for a significant time period and compliance with numeric DO criteria is required to the deeper zone at the POTS to protect cold water habitat. In the beginning and end of the summer there were days when temperature was constant from the surface to the bottom demonstrating that the pond was not stratified and was completely mixed. This variation in mixing demonstrates that thermal stratification, as influenced primarily by river flow and water temperature, is the dominant factor affecting mixing.

Gulf Island Pond Oxygenation Project (GIPOP)

The original GIPOP system began operation at Upper Narrows in 1992 utilizing a plenum diffuser ~ 300 feet long transverse to the direction of flow and with an oxygen transfer efficiency of ~ 33%. The system's operating parameters were outlined in Rumford Paper Co. and Verso's (formerly International Paper Co.) prior discharge permits as follows:

Begin GIPOP at Upper Narrows operation when the 3-day average temperature ⁽¹⁾ at the Turner Bridge is greater than 18°C in June.

Oxygen Injection Thresholds	% Normal Capacity	Oxygen Injection* (lb/day)
$Q^{(2)}$ > 3500 cfs	Idle	8,000
$T < 24^{\circ}\text{C}$ & $3,000 < Q \leq 3,500$	50%	36,500
$T < 24^{\circ}\text{C}$ & $2,500 < Q \leq 3,000$	75%	54,750
$T < 24^{\circ}\text{C}$ & $Q < 2,500$	100%	73,000
$T \geq 24^{\circ}\text{C}$ & $Q \leq 3,500$	125%	91,000

(1) All temperature ($T^{\circ}\text{C}$) measurements shall be obtained from the continuous temperature monitor at Turner Bridge and shall be expressed as a 3-day rolling average. Because the monitor records maximum and minimum temperatures for a given day, the daily average temperature will be defined as the arithmetic mean of the maximum and minimum temperatures for any given day. The 3-day rolling average is defined as the arithmetic mean of three daily average temperature values.

(2) All flow measurements, in cubic feet per second, shall be obtained from the USGS gage at Rumford and shall be expressed as a 3-day rolling average. The flow gage does record average daily flows; thus the 3-day rolling average is defined as the arithmetic mean of the three daily average flow values.

In June 2009, the GIPOP system at Upper Narrows was upgraded to increase the transfer efficiency of oxygen transfer to the water from 33% to 54%. The existing plenum diffuser was replaced with six line soaker hose style diffusers each running ~1300 feet longitudinally with the current and independently valved for control. Because the upgraded system was operated to inject the same amount of oxygen into the pond (in lbs/day, as a function of river flow and water temperature) as the original system, the net effect was an increase in the amount of oxygen actually transferred to the water column in GIP. Therefore there was an increase in DO levels in the pond during 2009 when compared to similar conditions in previous years.

In 2010, the system was upgraded again by removal of two Upper Narrows diffuser lines and the installation of two oxygen supply lines starting at the Upper Narrows and running ~9300 feet downriver to the Lower Narrows, where two 2600 foot long diffuser lines were installed parallel to river flow. The Lower Narrows diffuser was operational by June 30 with a predicted oxygen transfer efficiency of 75%. Due to increased efficiency, the total amount of oxygen needed was reduced from the original amount. The new system's operating parameters were modified from those of the original system by BEP order in June 2010 as shown below.

Begin GIPOP at Upper Narrows operation when the 3-day average temperature⁽¹⁾ at the Turner Bridge is greater than 18°C in June.

Oxygen Injection Thresholds	Oxygen Injection At Upper Narrows	Oxygen Injection At Lower Narrows	Oxygen Injection Total
$Q > 3,500$	0	0	0
$T < 24 \text{ & } 3,000 < Q \leq 3,500$	1,355	34,073	35,428
$T < 24 \text{ & } 2,500 < Q \leq 3,000$	5,210	31,989	37,199
$T < 24 \text{ & } Q \leq 2,500$	19,069	32,198	51,266
$T \geq 24 \text{ & } Q \leq 3,500$	24,279	34,490	58,769

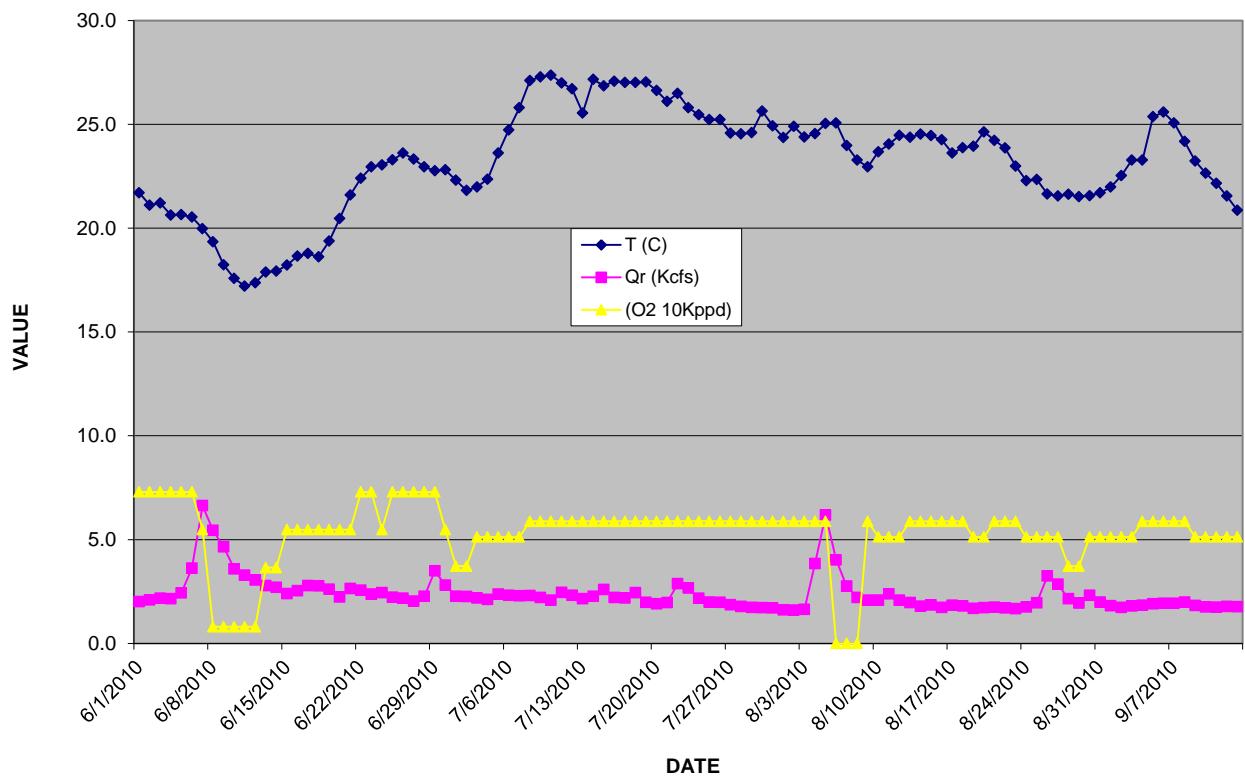
(1) All temperature measurements, in degrees Celsius, shall be obtained from the continuous temperature monitor at Turner (Center) Bridge and shall be expressed as a 3-day rolling average. The monitor records maximum and minimum temperatures for a given day. The daily average temperature is defined as the arithmetic mean of the maximum and minimum temperatures for a given day. The 3-day rolling average temperature (T) is defined as the arithmetic mean of three consecutive daily average temperature values.

(2) All flow measurements, in cubic feet per second, shall be obtained from the USGS gage at Rumford and shall be expressed as a 3-day rolling average. The gage records hourly flows. The daily average flow is defined as the arithmetic average mean of the hourly flows for a given day. The 3-day rolling average flow (Q) is defined as the arithmetic mean of three consecutive daily average flow values.

(3) This operational plan shall be evaluated annually and shall be modified as appropriate based on additional monitoring data, water quality modeling results, and any changes in licensed discharges.

Actual river temperatures and flows and oxygen injection rates are shown below (Figure 30). Because of relatively low river flows and high temperatures, the oxygen injection system was operated at the highest rate for much of the summer.

Figure 30. Temperature (T) and river flow (Q_r) at Rumford and oxygen injection (O₂) at Upper Narrows in June and at Upper and Lower Narrows in July, August, September, 2010



CONCLUSIONS

The summer of 2010 was a relatively dry one and river flows approached critical low flow (7Q10), making the summer a good one for evaluation of attainment of Water Quality Standards in the impoundment under critical conditions. By July 1, 2010 a second diffuser was installed at Lower Narrows to increase oxygenation of Gulf Island Pond. Consequently, water quality of Gulf Island Pond was improved over that of recent years, even in this summer of low river flow. The mean total phosphorus at Lower Narrows was similar to those of recent years and lower than that of 2004, the last year with an algal bloom. The mean chlorophyll-a concentration was similar to those of recent years and confirmed the trend of lowering levels from 2004 to 2008. Chlorophyll-a levels were below the threshold used for blooms in lakes (8 ug/l) and the interim threshold for Gulf Island Pond (10 ug/l). Secchi disk transparency was greater than the 2m threshold for phytoplanktonic algae blooms used for uncolored lakes for all dates and mean Secchi disk transparency was similar to those of recent years and greater than that of 2004. Aerial observations did not detect an algal bloom at Gulf Island Pond in 2010.

At all stations upstream of the Lower Narrows diffuser, DO concentrations were above both the minimum criterion of 5 mg/l and monthly average criterion of 6.5 mg/l (at a temperature of 22°C or less) for the entire summer except for one day at the old Lower Narrows sampling station prior to the beginning of operation of the new diffuser there July 1. At all stations below the Lower Narrows diffuser, DO concentrations were improved from previous years, but still below either the minimum criterion or monthly average criterion in the deeper coldwater portions of the impoundment for a significant amount of time. At station GIP4, DO concentrations were above the concentration and percent saturation minimum criteria for 7 of 9 sampling dates representing 78% of the sampling period, but below the criteria on 2 of 9 sampling dates representing 22% of the sampling period. The rolling monthly average DO concentrations exceeded the monthly average criterion for all 7 periods where it could be calculated. At the Deep Hole station, DO concentrations were above the concentration and percent saturation minimum criteria for 40% of the days, and 97% of the applicable measurements, but below the minimum criteria for 60% of the days, and 3% of applicable measurements and below the monthly average criterion for 87% of the days at applicable depths. Of the 3% of the total measurements that were below the minimum criteria, most were usually restricted to a narrow (1-3 m) band near or in the thermocline where there were suitable temperatures to support indigenous species of fish as required. Consequently, the lower DO levels there constitute non-attainment of Maine's Water Quality Standards.

The location of low DO concentrations in area of the thermocline and in still deeper layers where mixing is inhibited and attainment is not required, and higher concentrations of DO above the area of the thermocline suggests that sediment oxygen demand (SOD), resulting primarily from past inputs of total suspended solids, and settled algae from past inputs of nutrients, is likely the predominant cause of low DO levels there. Discharges from the mills increased slightly from recent years but were still below those from 2004 and within permit limits. It is expected that continued compliance with permit limits will further reduce SOD and allow full compliance with the DO criteria in time.

In 2010 water quality of Gulf Island Pond was the best since recent studies began in 2004 and likely the best in at least 75 years. This is no doubt due to reductions in discharges at the Rumford Paper Co. mill in Rumford, Verso Paper Co. mill in Jay, the closure of the Fraser Pulp

mill in Gorham, New Hampshire and improved oxygenation at the Upper Narrows diffuser and installation of the Lower Narrows diffuser. Monitoring needs to be continued to determine extent of compliance with Maine's Water Quality Standards.

References

Acheron, 2010. 2010 Androscoggin River and Gulf Island Pond Water Quality Monitoring Report. Submitted to the Maine Department of Environmental Protection, Augusta, Maine, November 30, 2010.

FPL, January 2011. Raw and summarized data from the continuous monitors in Gulf Island Pond submitted by CD and mail.

Appendices (available from DEP electronically)

1. GIP 2010 DEP Water Quality data
2. GIP 2010 Acheron Water Quality data
3. GIP 2010 FPL continuous Temperature and Dissolved Oxygen data